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School of Mines and Metallurgy
University of Missouri

BULLETIN

DECEMBER 1908

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BULLETIN
of the
School of Mines and Metallurgy
UNIVERSITY OF MISSOURI

VOL. I. DECEMBER, 1908 NO. 1

COMMENCEMENT ADDRESS

June 10, 1908

THE HUMAN SIDE OF A MINING ENGINEER'S LIFE

Edmund B. Kirby, E. M.
Manager Federal Lead Co., Flat River, Mo.

You have now reached the time when the care and sacrifices of your families are at an end, when faithful instructors have completed their labors, when the State has performed its duty. It is now in order for you to stand upon your own feet and to go your own way.

You are assembled here today to say farewell and to receive a few directions about the trail ahead. At such a moment we need no words from you to know the inquiry in every mind "Which way lies success for me?" To this question, so old and yet so new, the answer must ever be the same—"No man knows." We can, however, tell you where the chances are best and the dangers least. We can give pointers on equipment and a few friendly suggestions which will aid your journey.

So, first of all I say to you, that the way is long and hard. It leads over rough mountains and through treacherous swamps and disappearing, leaves you to break your own trail. Therefore, travel light. Look first to your load. Study the handicap which nature and fortune have placed upon you. So far you have not been responsible for this, but henceforth you are. Give it thought and care and little by little, by that persistent effort which never fails, you may throw it off and travel free.

And next, I would call your attention not to the Technical,

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but to the Human field before you. I do this, because it is so often neglected by mining engineers, and because this neglect is so apt to bring delay, disappointment, or failure. The special work of an engineer is to apply the discoveries and methods of science to the practical business of the world. Often he forgets how many-sided a man must be for this end, and then enthusiastic and absorbed in technical details, he overlooks the fundamental requirements of life.

I urge you, therefore, not to forget that the world is made up of things and of folks, and nine-tenths of your business is going to be with folks. Science is a fascinating but exacting goddess, and she brooks no rivals. She weaves a mystic spell about her devotees and normal Human motives disappear. The love of gold, the dream of power, the hunger for social position, are all forgotten. They find themselves impelled by strange, mysterious forces, unknown to the multitude, and by themselves but dimly understood. They pursue truth for truth's sake. They discover realities through the insatiable desire to know. Enthralled by the passion for exploration and discovery, they give profound intellectual effort, they expend lives of unsparing labor for a mere existence, often without the aid of recognition or of sympathy. Such men live apart and in a higher world.

The enthusiasm kindled in the student's heart by contact with the scientific spirit, can never die out. It is and must always be the inspiration of the mining engineer. But his own life work is of a different nature—it is most sternly practical. It is the production of wealth from the forces and materials of nature. It leads out of the library and the laboratory, and into the busy world of men and affairs. Year by year it calls more and more, not for the intense and narrow specialist, but for many-sided ability, for the well-balanced man. The practical business of an engineer seldom requires profound technical knowledge, but it does demand a working knowledge of men and skill in dealing with them. He can often prosper without the former, but without the latter his chances are small.. The special word I bring you today, therefore, is to seek for success among Human beings, and throw off the personal defects which handicap you in the world of men and women.

This school has done what it could for your equipment. It has performed the duty for which it was created; it has awakened and developed your intellect; it has acquainted you with the methods and resources of science and of your profession. You represent the conscientious labor of earnest men who have brought you all to a certain standard of mental and technical equipment. But your social equipment, that combination of personal qualities which is to help or hinder your career, has been left to chance. Fortune has bestowed upon you the accumulated result of individual heredity, of early associations and of other environments, and in no two men is this result alike. The only common training has been that due to your own student life, together for four years. This has knocked off corners and rubbed down rough places, and is generally recognized as one of the chief objects of a college education. So, as you stand today, varying in these personal qualities, I call your attention to the fact that henceforth you are your own architects and can re-construct as you please. To youth all things are possible, and you can, if you really wish it, change these qualities in any way you like.

You will gradually learn what is wanted. The business world is not interested in the details of your education. It is generally understood that the completion of a course like yours indicates that the man has made good in his first test; that he has carried through successfully his first serious undertaking. This gives promise for the future, and the fact of technical training assures ease in breaking a new man into the business. But you do not yet know that the questions an employer asks are merely these: Has he good sense above the average? What is his personal bearing and address?

You will find that a diploma is of little interest to others, but a likeable personality is a passport, good for life and in all countries. In time you are to discover that tact and diplomacy solve more problems than engineering formulas; that a memory for names and faces will help you more than one for minerals and rocks. Sooner or later you will know that good sense, that ability to decide which of any two things is the more important, is an asset beyond price. You will awake to the fact that valuable as is skill in the higher mathematics, it will never push you to the front like the ability to write a letter which will really do its work. How will you deal with people if not through language, that means by which your thought and will may reach the consciousness of others, that delicate and subtile medium necessary for the most simple affairs of daily life, yet capable under a Master's touch of swaying a multitude, of moving the world? How far have you learned its use? You have studied the reactions of chemistry, but how much have you learned of those subtle human reactions which break down indifference and create friendship?

If your training as engineers has been effective, it has bred in you the impulse to search out facts, however unpleasant they may be, and to look them squarely in the face. In sorting over your equipment, you who do not find yourselves compendiums of all the virtues, will not be lonesome. You have, moreover, the consolation of knowing that anything lacking is yours for the effort, if you want it hard enough.

But you say this wanders from engineering matters. These are the winning qualities for all men. I answer "Quite so, the successful mining engineer is the successful man."

The technical side of a mining engineer's work is and must remain its distinctive feature. Next to the fundamental requirements of life, its importance is conceded by all. Not only is it necessary for him to shape his social qualities and general attainments upon broad-gauge lines, but it is well to recognize that the technical knowledge demanded by the mining world is broadening. The single specialist of former days is now under a disadvantage.

Mining is pecularly subject to the caprices of fortune, to sudden changes and to the incessant shifting of conditions and of men. It is a varied and comprehensive business, at times so simple as to be within the powers of any man, again so complex as to demand every resource in the list of human attainments. It may call for profound and little-known specialties of science, for the leadership of men, and for the most skilled and experienced commercial powers. This wide scope and these incessant changes with their sudden promotions call for engineers who are broad enough to take advantage of the opportunities they present. What is most desired is the man with all-around training and general personal equipment, qualified to concentrate upon and acquire any specialty when necessary, but capable of being suddenly shifted and quickly adapted to any or all requirements of the business.

And now I would call your attention to the relation of a mining engineer to his profession. He will always owe it more than he can give, and the motives of obligation as well as those of policy, impel him to do all in his power for its welfare. This duty is the more imperative because it is a young profession, only a generation old, and is not yet mature or fully organized. It has only of late been generally known or understood by the business world. During its growth, with advancing recognition, the professional spirit has steadily increased. The American Institute of Mining Engineers was the first and the most powerful means of collecting and uniting a number of scattered specialists into one self-conscious profession. Its great and long continued work has been ably seconded by the numerous local Engineering Societies throughout the world.

But what is not so clearly recognized is the remarkable work of the Mining Journals in developing the professional spirit of engineers and the feeling of fraternity among all those soldiers of fortune who constitute the mining world. Their prompt and thorough collection of news from the remotest mining districts, the eager search for every scientific and technical discovery which might be of use, their pressure for the interchange of views; these have been doing a constructive work for the entire mining world, of which it is yet hardly conscious. Today these journals stand foremost among the forces which are welding mining engineers into closer relations with each other, and with the business interests which they serve. The growth of professional unity and interdependence has been also fostered by the continued spread of the modern idea that an engineer has more to gain than to lose by exchanging technical information with others. He parts only with what a single man can know, he receives the knowledge of a thousand men. A professson becomes powerful, it is able to second individual effort only in proportion to the growth of the fraternal and helpful spirit. It is the policy, as well as the duty of every engineer, to recognize this and to use his best efforts towards that end. Throughout your career aid your profession, its schools, its associations, its journals, and its members, and for every hour, for every dollar you give it, you will receive a hundred fold.

And now a few suggestions about your life work.

There are men who shut themselves up, and out of their inner consciousness evolve some great work, such as an invention, or a book. Occasionally also, men go into the wilderness and discover a mine. But such individual play is rare and its chances are small. The real business of the world is done by team-work, and you must qualify for this. It is done by innumerable bodies of men, each of which is under some kind of organization, intended to combine its units into an efficient human machine, capable of the business on hand. Now, every such machine, whether it be a baseball nine, a section gang, the force of a great steel-plant, a railway system, or an army, works more or less badly. The individuals who compose it, from the general to the private, from the business head to the lowest employee, have human weaknesses which are much alike, and the results are friction, loose joints, lost motion and sand in the gears. Nevertheless, the outfit goes creaking along, and usually gets there, often to its own surprise.

There are weak points in abundance, not only on the Human, but on the Technical side of every business. There is a best way to do each operation, from the handling of a shovel, up, and it is not always done in the best way. Moreover, methods, processes, and machines are constantly changing, constantly advancing. These two conditions, the imperfection of technical methods, and the faults of Human organization, will provide your openings. It is because of them that the world is so full of opportunities for men who have the combinations of sound technical training and good sense.

When, therefore, you hold a job, do not waste time in complaints and fault finding. You will continually see waste and loss, things which are wrong, things which need improvement. Others see them too. If you have sense you will notice everything, but will keep your mouth shut. Some day your chance will come. Your advice will be asked. Some day you will be given charge of a small piece of work, of a few men, and may then bring out your ideas by doing this work better and more cheaply than the man before you.

An able man will move up from any job and there are no rules for fortune. But in your profession the chances are generally somewhat better for those who are able to start as workmen, or in positions close to the working force. If the machine of which you are a part is too bad, get out, but while you are in any business organization, be loyal to it, hold up the hands of those above you, and keep your own work as free as possible from the faults you notice elsewhere.

Your duty now is to get busy. Get into action somewhere. If you cannot at once find work in the line desired, take anything temporarily. Concentrate yourself upon your job until sure that you are holding it down, and then turn your attention to other men and other work. Beyond this you will play the game as fortune and your own will dictate.

Play it straight. This may sound easy to you, fresh from the wholesome influences of your homes and the fair-play of boy democracy, but in years to come, when the passions of the fierce struggle take hold of you, when copy book maxims fail, when you see men around you winning safety, fortune, and power by unscrupulous methods, unless you have higher motives for honesty than the belief that it generally pays, you are quite likely to resign from the Straight Men's Association It is gratifying to be able to tell you that you will find your profession much above the average in its percentage of clean men.

It may sometime be of service to know that to be fired from a job is often the best thing that can happen to a man, if he is really built of the right stuff. It galvanizes him into life, jerks him out of a rut, tests his own resources, and makes him start fresh in new surroundings and with new people.

Throughout your career you will make errors and have occasional bad falls. Avoid the delusion that such occurrences are fatal. No error is serious, unless you fail to learn its lesson, or allow it to weaken your courage. Some of the most successful men I have known had failed so many times that they stopped remembering. Because they stopped, they succeeded. If by the caprice of fortune, any of you should eventually meet with disappointment, if you should fail to realize your hopes and ambitions, you will by that time, have learned that your only failure has been to escape the common lot of man. You will by that time understand the Arizona epitaph, "Life ain't in holding a good hand, but in playing a poor one well."

Under normal conditions your status will long be simply that of the Human animal, struggling for the existence of self and family, differing from other animals only in the complexity of itself, its environment, and its struggle. This struggle for existence is your first duty, and may long demand your whole attention. But for those of you who respond to the spirit of the age, the time should come, by middle life if at all, when your eyes will be lifted from the details of self seeking. You will suddenly become conscious of the great Human organism of which you are a part and of your relations to it. You will have attained intelligence. Thenceforth a part of the awakening soul of humanity you will see through the surface and into the injustice and unhappiness of the world around you. When this awakening comes, with the new duties it imposes upon your conscience, follow them. Choose what line of action you please, but do something. You may elect either to pick up wounded, or to get into the fighting line somewhere, but get busy. Join those who are trying to make the world a decent place to live in.

Your destinies will be determined by the mingled influences of ability, hard work, and pure luck. Capricious fortune will deal kindly with some of you and roughly with others. Some of you will reach wealth and power, others will not. As your head swells with success, do not forget how much of it is due to chance. Do not forget a struggling classmate. In a few months the petty differences and jealousies of your college life will have passed into oblivion, but the man who has rubbed shoulders with you through that experience, has a grip and pass-word that you cannot forget. Throughout the world, among the yellow, the brown, the black, and the white, it is the law that the call of a comrade must be heard.

And now, gentlemen of the Class of 1908, in behalf of the Profession of Mining Engineers, I welcome you to its ranks. No profession is more important, no one has a brighter future. It is your special work to bring forth the hidden treasures of the earth, and to convert them to the use of man. Yours is the mother of industries. Where mines are opened, there the wilderness blossoms into towns, railways, agriculture, manufactures, homes, and all the varied forms of civilized life. Yours is the creative work of pioneers, and your field is the world. Within a few years you will be scattered from the east to the west, from the tropics to the frozen regions of the north. Your duties lead you to the forest, to the mountains, and upon the desert. You are to labor in the roar of machinery, in the smoke of furnace-fires, and in the cities of candle-light. In time you are to become leaders of industry in distant places, to be entrusted with power over men under many skies. Wherever this may be, whether in the centers of our American civilization, or among strange peoples and amid strange tongues the State of Missouri expects you to bring honor to her name. Our profession looks to you to uphold and to advance its standards.

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SCHOOL OF MINES AND METALLURGY

University of Missouri

THIRTY-EIGHTH ANNUAL CATALOGUE

Rolla, Missouri
1909

1909

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CALENDAR.

1909.

March 22, Monday	Third Term Begins.
June 9, Wednesday	Annual Commencement.
June 14, Monday	Summer School Begins.
July 24, Saturday	Summer School Ends.
September 3, 4, Friday and Saturday	Entrance Examinations.
September 6, Monday	Registration for First Term.
September 7, Tuesday	First Term Begins.
November 25, Thursday	Thanksgiving Holiday.
December 22, 4 P. M. Wednesday	Christmas Recess Begins.

1910.

January 3, Monday	Registration for Second Term.
January 4, Tuesday	Second Term Begins.
February 22, Tuesday	Holiday.
March 12, Saturday	Registration for Third Term.
March 14, Monday	Third Term Begins.
June 1, Wednesday	Annual Commencement.

BOARD OF CURATORS.

S. L. Baysinger	Rolla, Mo.
B. H. Bonfoey	Unionville, Mo.
P. E. Burton	Joplin, Mo.
C. B. Faris	Caruthersville, Mo.
David R. Francis	St. Louis, Mo.
J. V. C. Karnes	Kansas City, Mo.
J. C. Parrish	Vandalia, Mo.
Curtis B. Rollins	Columbia, Mo.
Campbell Wells	Platte City, Mo.

OFFICERS OF THE BOARD.

C. B. Faris	President.
J. V. C. Karnes	Vice-President.
J. G. Babb	Secretary.
R. B. Price	Treasurer.

EXECUTIVE COMMITTEE
of the
SCHOOL OF MINES AND METALLURGY.

C. B. Faris	Caruthersville.
J. C. Parrish	Vandalia.
P. E. Burton	Joplin.

OFFICERS OF THE COMMITTEE.

C. B. Faris	Chairman.
J. A. De La Vergne, Jr.	Secretary.
Henry Wood	Treasurer.

Director of the School.
LEWIS E. YOUNG.

Secretary of the Faculty,
JOHN B. SCOTT.

Registrar,
J. A. DE LA VERGNE, JR.

Librarian,
JESSIE HELLER.

Superintendent of Buildings and Grounds,
ROBERT R. DICKERSON.

FACULTY.

Albert Ross Hill, A. B., LL. D. *President of the University.*
A. B., Dalhousie University, 1892; Ph. D., Cornell University, 1895; LL. D., University of South Carolina, 1905; Dalhousie University, 1908.

Lewis Emanuel Young, E. M. .... *Director.*
B. S. in Mining Engineering, Pennsylvania State College, 1900; E. M., Iowa State College, 1904.

George Reinald Dean, C. E. .... *Professor of Mathematics.*
C. E., School of Mines, 1890; B. S. in Mathematics and Physics, School of Mines, 1891.

Austin Lee McRae, S. D. .... *Professor of Physics.*
B. S. University of Georgia, 1881; S. D., Harvard University, 1886.

Victor Hugo Gottschalk, M. S.. *Professor of Chemistry.*
B. S. in Chemistry and Metallurgy, School of Mines, 1898; M. S. School of Mines, 1900.

Elmo Golightly Harris, C. E. .... *Professor of Civil Engineering.*
C. E., University of Virginia, 1882.

Durward Copeland, S. B. .... *Professor of Metallurgy.*
S. B., Massachusetts Institute of Technology, 1903.

Leon Stacy Griswold, A. B. ... *Assistant Professor of Geology and Mineralogy.*
A. B. Harvard University, 1889.

Joseph Henry Bowen.. *Assistant Professor of Shop Work and Drawing.*
Graduate, Miller School, Va.

Leon Ellis Garrett, B. S. ...... *Assistant Professor of Mathematics.*
B. S. in General Science, School of Mines, 1901.

Robert Clair Thompson, M. S.. *Assistant Professor of Chemistry.*
B. S., Westminster College, Pa., 1900; M. S., School of Mines, 1904.

FACULTY—Continued

PAUL JULIUS WILKINS, B. S...... *Instructor in Modern Languages.*
B. S., Michigan A. & M. College, 1869.

JOHN BENNETT SCOTT, B. S...... *Instructor in English and Secretary.*
B. S. in General Science, School of Mines, 1907.

EDWARD STAPLES SMITH, M. E..... *Instructor in Drawing.*
M. E., Brown University, 1904.

GEORGE WATSON COREY, E. M..... *Instructor in Mineralogy.*
B. S. in Mining Engineering, Michigan College of Mines, 1903; E. M., Michigan College of Mines, 1906.

BOYD DUDLEY, JR., B. S........... *Instructor in Metallurgy and Ore Dressing.*
B. S. in General Science, School of Mines, 1908.

DIBRELL PRYOR HYNES, B. S....... *Instructor in Chemistry.*
B. S. in General Science, School of Mines, 1908.

JAMES VANCE HOWE, B. S... *Instructor in Civil Engineering.*
B. S. in Civil Engineering, University of West Virginia, 1903.

HORACE THARP MANN, B. S....... *Instructor in Metallurgy.*
B. S. in Mining Engineering, School of Mines, 1908.

FRANK CRAIG LIVINGSTON, LL. B. *In Charge of Gymnasium Equipment.*

HECTOR GEORGE SYLVESTOR ANDERSON........ *Assistant in Metallurgy.*

DEFORREST DON.................. *Assistant in Mineralogy.*
WILLIAM ALBERT BAUERIS.......... *Assistant in Surveying.*
EDWARD PHILLIP BARRETT.......... *Assistant in Chemistry.*
ARTHUR LEWIS POLLARD.............. *Assistant in Physics.*
HARVEY ODEN GARST.............. *Assistant in Surveying.*
ALBERT PARK...................... *Assistant in Surveying.*
DAVID LAWTON FORRESTER........... *Assistant in Drawing.*

FACULTY COMMITTEES.

Admission.

Professors Dean, Wilkins, and Griswold.

Athletics.

Professors Thompson, Bowen, McRae, and Copeland.

Buildings, Plant, and Grounds.

Professors McRae and Harris.

Degrees.

Professors McRae, Scott, and Dean.

Examinations and Schedule.

Professors Bowen, Griswold, and Garrett.

Graduate Courses.

Professors Gottschalk and Copeland.

Theses.

Professors Harris, Copeland, and Griswold.

Undergraduate Courses.

Professors Dean, McRae, Griswold, and Gottschalk.

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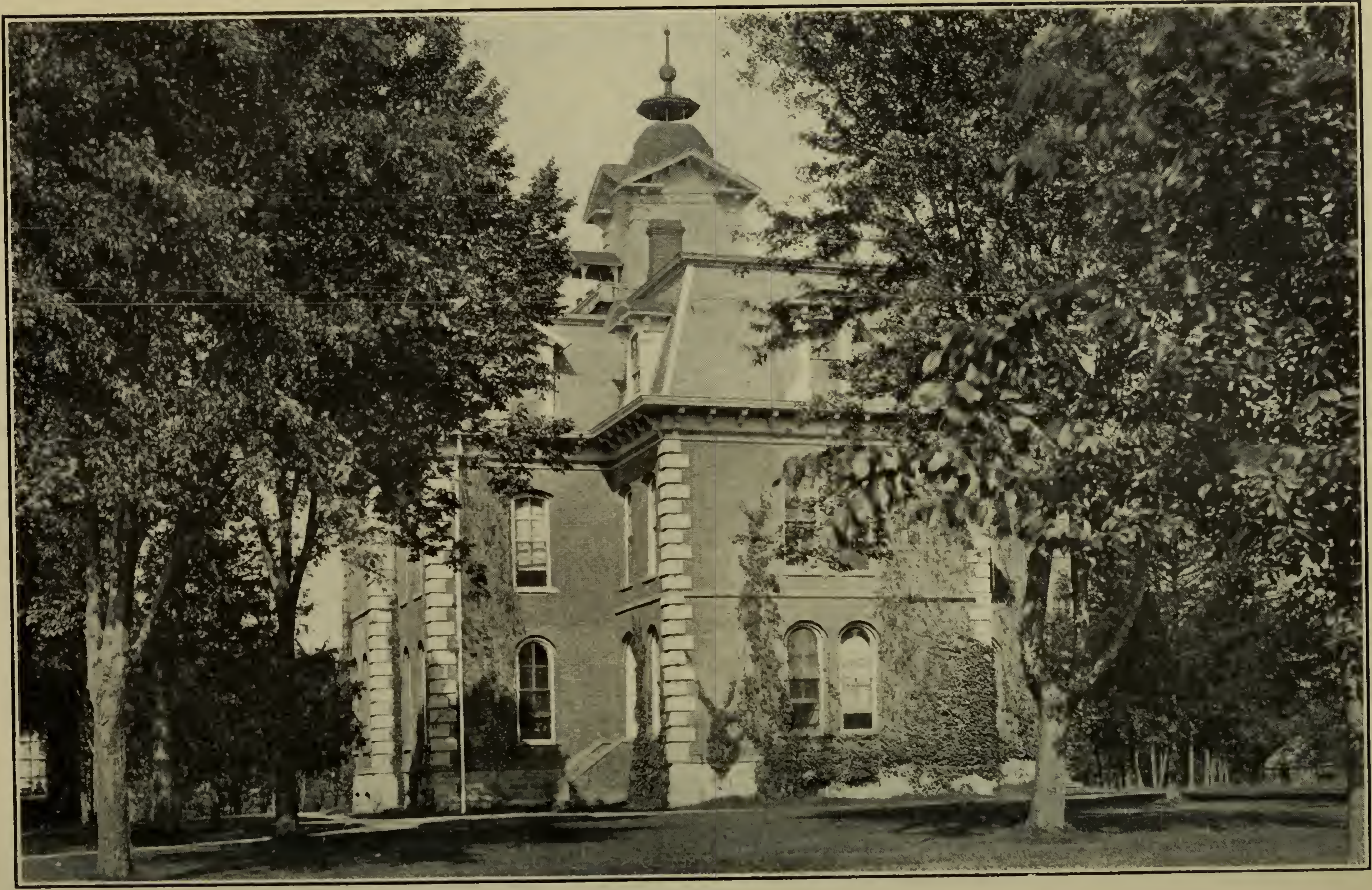

ROLLA BUILDING

HISTORY OF THE SCHOOL.

In 1870 the General Assembly of Missouri, in accepting the donation of land for educational purposes made by the General Government through an Act of Congress, approved July 2, 1862, established an Agricultural and Mechanical College and a School of Mines and Metallurgy. The design of these institutions is set forth in the following language:

Objects of the Colleges.—The leading objects of said colleges shall be to teach such branches as are related to agriculture and the mechanic arts and mining, including military tactics, and without excluding other scientific and classical studies, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. (R. S. 1899, Sec. 10504-10521.)

The School of Mines and Metallurgy was located at Rolla, Phelps County. Here, in November, 1871, the school was formally opened. The statutes fix the status of the School as one of the Colleges of the State University. Its affairs are under the immediate supervision of an Executive Committee, consisting of three members of the University Board of Curators, selected by that body. The need of general culture as a foundation and accompaniment of specifically technical training, led to the establishment, in 1885, of an Academic Course in compliance with the following Act of the General Assembly:

Academic Course of Study.—That the obligations of the State to the General Government, assumed by the acceptance of the land grant of July 2, 1862, may be more fully discharged, and in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life, the Board of Curators of the State University shall prescribe and adopt a liberal Academic Course of Study to be taught in the College of Mines and Metallurgy, located at Rolla, in addition to the courses now taught in said school, and may confer the degree of Bachelor of Science upon all students who shall complete said course in said school to the satisfaction of the faculty thereof. (R. S., Sec. 10504-10521.)

FINANCES.

The proceeds from the sale of the public lands granted by the General Government amount to about $350,000, which is invested in State certificates of indebtedness bearing 5 per cent interest. The School of Mines receives one-fourth of the yearly income thus accruing.

By an Act of Congress, approved August 30, 1890, commonly known as the 'Morrill Bill,' the General Government donated to each State and Territory maintaining a college or colleges in accordance with the act of July 2, 1862, $25,000 a year. After deducting one-sixteenth of this fund for the Lincoln Institute, Missouri gives one-fourth of the remainder to the School of Mines.

In 1891, the Government returned to the various States the sums collected from their citizens by the imposition during the Civil War of a 'direct tax.' The amount thus refunded to Missouri was $646,958.23, and the Thirty-sixth General Assembly of the State won the gratitude of the friends of higher education by establishing this as a permanent endowment for the State University at Columbia, and the School of Mines and Metallurgy at Rolla. One-fifth of the income from this endowment, amounting to $6,469.58 per annum, is received by the School of Mines.

The Fortieth General Assembly of the State passed an act providing for a tax on collateral inheritances for the benefit of the State University, and the Forty-first General Assembly has provided that one-fifth of the funds derived from this tax shall be appropriated for the benefit of the School of Mines.

ENDOWMENT.

The State endowment of the School of Mines is set forth in the following extracts from the Statutes of Missouri:

"The proceeds of the sale of lands donated to the State of Missouri by the United States for the support of the College of Agriculture and Mechanic Arts and the School of Mines and Metallurgy, by act of Congress, approved July 2, 1863, represented by state certificates of indebtedness, of the following amounts and dates:

July 2, 1883	$242,000.00
November 1, 1883	5,000.00
January 29, 1884	5,000.00
April 19, 1884	35,000.00
April 2, 1885	5,000.00
February 25, 1886	5,000.00
January 1, 1888	5,000.00
December 15, 1888	5,000.00
May 15, 1889	5,000.00
July 1, 1891	5,000.00
May 15, 1893	5,000.00
July 1, 1895	22,881.19
April 9, 1895	5,000.00
Representing a total of	$349,881.19

Now issued or any certificates which may hereafter be issued under any general or special act of the General Assembly; one-fourth of the interest of these funds shall be paid to the Treasurer of the School of Mines and Metallurgy, at Rolla, for the maintenance of said institution."

"The proceeds of sales of lands donated to the School of Mines and Metallurgy at Rolla, represented by the State certificate of indebtedness of $2,000, dated April 15, 1893, issued under act March 31, 1883, interest on which shall be applied to the maintenance of the School of Mines and Metallurgy at Rolla."

"The State certificate of indebtedness of $3,000, issued under act of April 1, 1895 (pages 278 and 281, Laws 1895), dated April 1, 1896, four-fifths of the interest to be applied to the maintenance of the State University at Columbia and one-fifth to the School of Mines and Metallurgy at Rolla, and also any other certificates which may hereafter be issued and held in trust for this fund under any general or special act of the General Assembly." (R. S. 1899, Sec. 10522.)

"The State certificate of indebtedness of $646,958.23, derived from 'direct tax' received from the United States, dated April 1, 1891, issued under act of March 26, 1891, four-fifths of the interest to be applied for the maintenance of the State University at Columbia, and one-fifth for the School of Mines and Metallurgy at Rolla." (R. S. 1899, Sec. 10522.)

"All sums collected under the provisions of an Act of Congress, approved August 30, 1890, commonly known as the 'Morrill Bill,' shall be paid as follows: One-sixteenth thereof for the benefit of the Lincoln Institute and one-fourth of the remainder to the Treasurer of the School of Mines at Rolla, Missouri." (R. S. 1899, Sec. 10533.)

Collateral Inheritance Tax.—"The moneys received by the State Treasurer under the provisions of this article shall be deposited in the State Treasury to the credit of the fund now existing in the State Treasury, and known as the 'State Seminary Moneys,' for the maintenance, support and better equipment of the buildings, apparatus, books, instruction, etc., of the University of the State of Missouri, to an amount not exceeding in any one year the equivalent of one-tenth of one mill for every dollar of the assessed valuation of taxable property of the State for the said year; **Provided,** that one-fifth of all such moneys so received shall be devoted to the use of the School of Mines and Metallurgy, a department of the said University." (Session Acts, 1901, Section 302.)

LOCATION.

The School of Mines is located at Rolla, the county seat of Phelps County, on the St. Louis and San Francisco Railroad, approximately half-way between St. Louis and Springfield.

Rolla is on the crest of the Ozark uplift, at an elevation of eleven hundred forty feet above the sea level, and has an agreeable and notably healthful climate. Its position on a great transcontinental railway system makes it readily accessible.

The school is within easy reach of the important mining districts of the State, which offer splendid facilities for the study of mining geology, mining methods, ore dressing, and mining machinery. Numerous recent improvements, due to the systematic study of Missouri ore deposits, methods of ore treatment, and the extensive development of low-grade lead and zinc ores have given the school advantages for the application of the theories of geology, mining, and ore dressing to practice.

The smelting industry of the State is very important and every courtesy is extended to the professors and students of the school during their visits to these metallurgical plants. The methods of mining coal and clay can be readily studied in Missouri and the adjoining fields. Numerous clay-working and cement plants in St. Louis and the vicinity offer good opportunity for the study of these important industries. In and about St. Louis are also various chemical plants which are visited from time to time.

CAMPUS AND ATHLETIC FIELD.

The grounds of the School of Mines are situated in the highest part of the City of Rolla, and are over twenty-seven acres in extent. The campus contains beautiful lawns, groves of native oak, and many shade trees.

The athletic field has a good baseball diamond, a football gridiron, tennis courts, a 220-yard oval running track, and a 200-yard stretch for sprints and hurdles. On the athletic field there is a suitable building providing shower baths and a dressing room for the various athletic teams.

BUILDINGS.

Rolla Building.

This building was originally built by the City of Rolla as a High school building, but was sold to the State in 1871, and for many years was the principal building of the School of Mines and Metallurgy. It is a brick structure, ninety feet by sixty feet, four stories high, including a working basement. It contains the library, laboratories, drafting rooms, offices, and geological collections of the State Geological Survey, recitation rooms for mathematics and modern languages, toilet, shower baths, and locker rooms.

Chemical Hall.

The main portion of this building was erected in 1885 and two wings were added in 1902. The main building is two stories high and one hundred two feet in length by fifty-five feet in width. Each wing is fifty-five feet by sixty feet and one story high. This entire building, including a large basement, is used for chemistry.

Mining Building and Power Plant.

This building, erected in 1895, is a tile-roof, press-brick structure, and consists of two distinct portions, one containing offices, a class-room, and laboratories—the other comprising a large mill-room and mining laboratory, an engine-room, and a boiler-room. Suitable offices are provided in this building for the professor of mining engineering and for the superintendent of buildings and grounds.

Mechanical Hall.

This two-story brick building, erected in 1901, is one hundred fifty feet by sixty feet and was specially designed for mechanical work. The second floor includes a demonstration lecture room, a shop for bench-work in wood, and a temporary gymnasium. The first floor contains a lathe room for wood-turning, a forge room, a metal-working room, and a stock and tool room.

Each floor is provided with a lavatory and lockers and an office for the instructor.

Norwood Hall.

The corner stone of this building was laid November 23, 1902, and the building was first used in 1903. It contains adequate quarters for the demonstration offices, and provides lecture and recitation rooms for physics, geology, mineralogy, civil engineering, English, mathematics, also drawing rooms and laboratories for physics, geology, mineralogy, and civil engineering. The school library is located on the first floor of Norwood Hall.

Ore Dressing Building.

This is a three-story gray press-brick building, forty-five by one hundred six feet, with a basement and two large one-story wings. Although the building has not been completed, two stories and the west wing have been in use since January, 1908. The building is to provide quarters for metallurgy and ore dressing.

Director's Residence.

This is a two-story brick and frame building, erected in 1889 and used for a number of years as a student club-house and dormitory.

Athletic Building.

A one-story frame building, thirty-seven by thirty-four feet, formerly used as a wood shop, is now used by the athletic teams and provides dressing rooms, lavatory, and store room for athletic supplies.

Carpenter Shop.

The general repair work of the school and construction of laboratory equipment is carried on in a frame building, ninety feet by twenty-two feet. This building is located west of Mechanical Hall and includes a store room for lumber.

LIBRARY.

The Library contains about eight thousand carefully selected volumes and several thousand pamphlets and bulletins. Good collections of works on Engineering, Mathematics, Chemistry, Physics, Mining, Metallurgy, Ore Dressing, Geology, and Mineralogy, afford to students an opportunity to pursue an extended course of reading in connection with their class work. The Library also contains the standard works in English and American poetry, fiction, biography, and history. It is well provided with encyclopedias and works for general reference.

The Library is the depository for the maps, drawings, photographs, and lantern slides of the school. A splendid series of several thousand photographs of Missouri mines, mills, and smelters is on file and indexed so that it is easily accessible. Photographs have been secured from most of the important mining camps of the world, and the student has the opportunity to supplement the daily lectures by reference to these selected illustrations.

The valuable collection of between two thousand and three thousand maps and drawings are indexed and are used to supplement work in the class room and in the drafting room.

All of the important technical periodicals and reports are received regularly, together with general magazines which are of interest to engineers and scientists.

Current and recent technical literature plays such an important part in present-day education that an elaborate card index of technical literature has been provided and is maintained up-to-date. More than 25,000 important articles in transactions of societies, reports, bulletins, and periodicals have been recorded and classified.

A well-lighted room, thirty-nine feet by forty-five feet, has been furnished in an attractive manner for the reading room. It is located on the first floor of the building and is adjacent to the stack room.

The Library is open from 9 A. M. until noon, from 1 P. M. to 5 P. M., and from 7 P. M. to 9 P. M., daily except Sunday.

LIBRARY
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VIEW ON THE CAMPUS

ADMISSION.

Under the statutes persons of either sex, sixteen years of age or over, whether residents of Missouri or not, may be admitted upon evidence of sufficient preparation. Students should have a good liberal education, its elements at least, before beginning technical study. The average age of members of the present Freshman class at entrance was about eighteen years. Specific requirements have been fixed by considerations of the express design of the school—"to promote the education of the industrial classes" in certain branches of engineering—and of the educational opportunities of its intended beneficiaries. The requirements for admission to the Freshman class are as follows:

The applicant must file with the Director a satisfactory certificate of good moral standing.

Admission by Examination.—Applicants for admission, not having diplomas from approved schools, are required to pass, without conditions, examinations in fifteen units, a unit being the equivalent of a year's work in one subject, as given in an approved high school.

Of these fifteen units the following are required: Three units in English, two units in Algebra, one unit in Plane Geometry, and one-half unit in Solid Geometry. The remaining eight and one-half units may be selected from the following list:

Subject.	Maximum.	Minimum.
English	4	3
Algebra	2	2
Plane Geometry	1	1
Solid Geometry	½	½
Plane Trigonometry	½	½
History	4	1
Latin	4	1
Greek	3	1
German	3	1
French	3	1
Spanish	3	1
Physics	2	1
Chemistry	2	1
General Biology	2	1
Zoology	2	1
Botany	2	1
Drawing	1	1
Shopwork	1	1
Civil Government	½	½
Physiology	1	1
Physiography	1	1

Mathematics.—The four units which may be offered in mathematics are as follows:

Algebra. Two units. Elementary algebra, including the elementary operations, solution of simple and simultaneous linear equations, factoring, radicals, exponents, quadratic equations, equations containing radicals, imaginaries, simultaneous quadratics, higher equations solved as quadratics, relations of roots and co-efficients of quadratics and higher numerical equations, solution of higher equations by factoring, Horner's method of approximation, binomial theorem for positive integral exponent, ratio and proportion, and logarithms.

While the study of these particular subjects is recommended, it is not expected that the student shall be able to pass an examination on each and every one of them. He must produce evidence, however, of having studied algebra for two years under a good teacher in an accredited high school.

Plane Geometry. One unit. The work in Plane Geometry must cover a full year in any good text. It is recommended that considerable attention be paid to the applications of algebra to geometry, and of geometry to algebra and arithmetic.

Solid Geometry. One-half unit. A full half-year's work is required in Solid Geometry. The same recommendations apply here as in Plane Geometry, with the additional requirement that the student be drilled in arithmetical work in computing areas and volumes.

Trigonometry. One-half unit. It is to be understood at the outset that this work will not be accepted for advanced standing. This branch of mathematics is of such great importance to the practical engineer that the whole subject must be reviewed, and the student led to a point of view which it is impossible to attain in a high school course.

History.—Four units may be offered in history; one each in Ancient History, Medieval and Modern History, English History, and American History.

Civil Government. One-half unit may be offered in Civil Government. This is the equivalent of one-half year's work in the fourth year of a high school and the applicant should have a knowledge of the chief organs of local, state, and national government, and a knowledge of the historical development of the government.

Physiography.—A student may offer one unit in physiography. A description of this unit will be sent on request.

Physics.—The two units that may be offered in physics are as follows:

1. A year's work, five periods per week, of which at least two must be double periods in individual laboratory work. At least thirty-five exercises, selected from a list of sixty or more, equivalent to those recommended by the National Educational Association, must be completed.
2. A continuation of the laboratory for another year, or a year's work in a more advanced text together with the laboratory work.

Laboratory note-books must be presented by those who are required to take the entrance examination.

Drawing.—One unit may be offered in drawing and is as follows:

A year's thorough work in freehand drawing, or in mechanical drawing, or in a combination of the two. This unit is the equivalent of five laboratory periods per week throughout the year. Drawings must be presented by students desiring credit in this subject for entrance. This unit will be accepted for admission but not for advanced standing.

Freehand. The ability to draw and paint natural growths (leaves, flowers); to give correct proportions, perspective, and light and shade in drawing from geometric solids, vases, etc.; to paint with water colors from simple objects (fruit vases); to make designs suitable for book covers and school programs, in black and white and in color.

Mechanical. Use of instruments and plain lettering; simple geometrical problems; plain freehand lettering and dimensioning; plans, elevations, and cross-sections; development of the *idea of plan, elevation* and *section* from geometrical solids; drawing accurately to scale plans, elevations, and sections from pupil's own measurements; and dimensioned freehand sketches of simple machine parts; plan and elevation of some building measured by pupils. The explanation and practice of isometric and cabinet views as applied especially in joinery.

Combination. The ability to draw, as outlined under the Freehand Course, without the painting; the use of the instruments, plain lettering, the drawing of simple plans and elevations as outlined under the Mechanical Course.

Manual Training.—One unit may be offered in manual training and the candidate must give satisfactory evidence of having completed a year's work of five periods per week of at least one and one-half hours each. This work will not be accepted for advanced standing.

Latin.—The four units that may be offered in Latin are as follows:

1. Collar and Daniell's First Latin Book, or the equivalent.
2. Three books of Caesar's Gallic War with composition based thereon in Moulton and Collar's Preparatory Latin Composition or in Daniell's New Latin Composition. For one book of the Gallic War the equivalent in time of Viri Romae, Nepos, or Eutropius may be offered.
3. Two additional books of the Gallic War and four Orations of Cicero with compositions based thereon in the books mentioned above.
4. Ovid's Metamorphoses (2,000 lines) and four books of Vergil's Aeneid, with prosody.

Greek.—The three units that may be offered in Greek are as follows:

1. Ball's Elements of Greek, or White's First Greek Book.

2. Four books of Xenophon's Anabasis, Pearson's Greek Prose Composition, or its equivalent, Goodwin's Greek Grammar.

3. Ten orations of Lysias and the first four books of Homer's Odyssey, or an equivalent amount of other Greek authors. Bridgman's Parallel Exercises based on Lysias.

German, French, Spanish.—Three units may be offered in German, French, or Spanish. A description of the units will be sent on request.

Chemistry.—The two units that may be offered in chemistry are as follows:

1. A year's work in chemistry, five periods per week, of which at least two must comprise laboratory work.
2. A second year's work in the subject, five periods per week, of which at least two must be laboratory work.

Note-books showing work done must be presented by those who are required to take the entrance examination.

These courses will be accepted for admission but not for advanced standing.

Admission on Diploma.—Applicants may be admitted upon certificate from a college, high school, or preparatory school when the Faculty is satisfied that the work certified to covers the requirements of the School of Mines and Metallurgy.

Each applicant must file with his diploma a statement, on a School of Mines and Metallurgy blank, from his superintendent or principal, showing that the applicant has to his credit fifteen units.

Following is a list of schools whose courses have been approved by the University, and whose diplomas will admit to the Freshman class without examination.

ACCREDITED SCHOOLS.

Albany High School
Alton (Ill.) High School
Appleton City Academy
Aurora High School
Bartlesville (Okla.) High School
Bethany High School
Blees Military Academy, Macon
Bloomfield High School
Bonne Terre High School
Boonville High School
Braymer High School
Breckinridge High School
Brookfield High School
Butler High School
Cairo (Ill.) High School
California High School
Cameron High School
Carleton College
Carrollton High School
Carterville High School
Carthage High School
Caruthersville High School
Centralia High School
Charleston High School
Chillicothe High School
Clinton High School
Columbia High School
Covington (Ind.) High School
Culver (Ind.) High School
Davenport (Ia.) High School
De Soto High School
Dexter High School
Doniphan High School
East St. Louis (Ill.) High School
Elmwood Seminary
Enid (Okla.) High School
Everton High School
Excelsior Springs High School
Ferguson High School
Flat River High School
Fort Scott (Kan.) High School
Fort Smith (Ark.) High School
Fredericktown High School
Gallatin High School
Grant City High School
Greenfield High School
Greenville (Miss.) High School
Guthrie (Okla.) High School
Hamilton High School
Hannibal High School
Hardin College, Mexico
Harrisonville High School
Higginsville High School
Hopkins High School
Hot Springs (Ark.) High School
Iberia Academy
Independence High School
Jackson Military Academy
Jefferson City High School
Joplin High School
Kahoka High School
Kansas City (Kan.) High School
Kansas City Central High School
Kansas City Manual Training School
Kemper Military Academy, Boonville
Kennett High School
Keokuk (Ia.) High School
Kewanee (Ill.) High School
King City High School
Kirksville High School
Kirkwood High School
Lamar High School
Lancaster High School
La Plata High School
Leavenworth (Kan.) High School
Lebanon High School
Lee's Summit High School
Lexington High School
Liberty High School
Linneus High School
Lockwood High School
Logan County High School (Guthrie, Okla.)
Louisiana High School
Macon High School
Maitland High School
Malden High School

Marionville Collegiate Institute
Marshall High School
Maryville High School
Memphis High School
Mexico High School
Michigan Military Academy (Orchard Lake, Mich.)
Milan High School
Missouri Wesleyan College
Moberly High School
Montgomery City High School
Mound City High School
Mt. Vernon High School
Muskogee (Okla.) High School
Nevada High School
Norborne High School
Oklahoma City (Okla.) High School
Oregon High School
Palmyra High School
Paola (Kan.) High School
Paris High School
Pierce City High School
Pine Bluff (Ark.) High School
Poplar Bluff High School
Princeton High School
Quincy (Ill.) High School
Rich Hill High School
Richmond High School
Ridgeway High School
Rogers Academy (Rogers, Ark.)
Rolla High School
St. Charles High School
St. Charles Military Academy
St. Joseph High School
St. Louis Central High School
St. Louis McKinley High School
St. Louis Manual Training School
St. Louis Yeatman High School
Savannah High School
Sedalia High School
Shelbina High School
Shelbyville High School
Sikeston High School
Slater High School
Smith Academy
Springfield High School
Steelville High School
Sweet Springs High School
Tipton High School
Trenton High School
Troy High School
Tulsa (Okla.) High School
Unionville High School
University Military Academy (Mobile, Ala.)
Vandalia High School
Walther College, St. Louis
Warrensburg High School
Washington High School
Webb City High School
Webster Groves High School
Wellston Station High School, St. Louis
Wentworth Military Academy, Lexington
West Plains High School
Western Military Academy
Westport High School
William Woods College, Fulton
Windsor High School

Advanced Standing.—Candidates may be admitted to advanced standing either upon examination in the subjects of the previous year or years, or upon certificate from another institution, of work accomplished, which is, in the estimation of the Faculty, equivalent to that completed here by the class into which entrance is sought. Applicants for advanced standing should communicate with the Director as early as possible, and all claims for advanced standing, in order to receive recognition, must be made by the student within one term after entrance.

Special Students.—Special students will be admitted without passing the regular examinations required for entrance, under the following conditions: 1. They must be at least twenty-one years of age. 2. They must show good reasons for not taking a regular course. 3. They must pass such examinations or other tests as shall demonstrate fitness to pursue profitably all the subjects selected by them. 4. They shall not be candidates for a degree. 5. Special students are expected to do particularly good work in the subjects which they choose. If, at any period of the session, their work becomes unsatisfactory, their connection with the school will be severed. When the work is chiefly of a laboratory nature they will be required to take at the same time as much classroom work as the Faculty may designate for each particular case.

Since there are many persons who would profit by the opportunities for education offered at the school, but who are unable, through lack of time or preliminary training, to undertake the work of the regular course, the Faculty has made the above provision. In this way it hopes to broaden the usefulness of the school, and to enable it to fulfill its purpose in as liberal a manner as possible.

DEGREES.

1. The degree of Bachelor of Science in Mining Engineering, Bachelor of Science in Metallurgy, or Bachelor of Science in Civil Engineering, will be conferred on students who have attained the required standard in all the subjects of instruction in Courses I., II., or III., and who submit satisfactory thesis.

2. The degree of Bachelor of Science will be conferred on students who have satisfactorily completed Course IV., and who submit a satisfactory thesis.

3. The degree of Master of Science will be given to students who, having graduated in Course IV., complete satisfactorily a year's post-graduate work in residence at the school, and demonstrate their ability by research work and a thesis.

4. The degree of Engineer of Mines, Civil Engineer, or Metallurgical Engineer, will be conferred on one who, having previously been graduated in Course I., II., or III., has completed satisfactorily a year's post-graduate work in residence, or who has had professional experience in a responsible position for not less than three years. A satisfactory thesis recording the result of some original investigation or independent research in a subject connected with his course, accompanied by such drawings as may be necesary to illustrate it, are required of all candidates for advanced degrees.

THESES.

All Seniors carry on special investigations during the third term and the results of this work are embodied in a thesis. The subject of the thesis must be reported to the Thesis Committee and approved not later than February 1st and the completed thesis filed with the Director not later than May 20th. The finished thesis must be typewritten on eight and one-half by eleven-inch paper with a one and one-half inch margin on the left to permit of binding in book form.

COURSES OF STUDY.

It is the object of the instruction at this institution, first, to lay a broad and solid foundation by acquaintance with principles and theory, and to supplement this, wherever possible, by the discipline of practical application in the laboratory and field. Lectures and recitations are arranged for the morning hours, leaving the afternoon for laboratory and field work. The practical work is designed to illustrate and impress principles, to familiarize the student with the use of instruments with which he is to be concerned in the work of his profession, and to afford an opportunity for original investigation. What is taught orally in the lecture room is applied and illustrated in the laboratory.

The School of Mines offers four regular courses leading to degrees.

I. *Mining Engineering.*
II. *Metallurgy.*
III. *Civil Engineering.*
IV. *General Science.*

The first is a general course in Mining Engineering having in view all of the operations in connection with mining, from the prospecting to the delivery of the finished product on the market. Instead of the regular work outlined for the Senior year in the Mining Engineering course, a student who has satisfactorily completed the work of the first three years of this course may elect one of the three optional courses outlined on pages 36, 37, and 38. These options are in Mining Geology, Mining Machinery, and Ore Dressing. They are planned for men who desire to specialize in the particular subjects mentioned and all lead to the degree of Bachelor of Science in Mining Engineering.

The second course contemplates especially processes in metallurgy subsequent to the delivery of the ore above ground. It fits a man for positions in connection with concentrating plants and smelters and various branches of industrial chemistry.

The third is a course in engineering as applied especially to railways, highways, and municipal works.

The fourth is largely elective and provides for a liberal education in General Science.

The engineering courses are practically the same in the Freshman year, and differ but slightly in the Sophomore year, The student has thus an opportunity to defer his choice of a specialty until he has spent some time in technical study, and can better estimate his inclinations and capacities.

One hour is given to each recitation or lecture period. The afternoon periods are given to drawing, laboratory, and field work and are of three hours' duration.

SPECIAL COURSES.

In addition to the four regular courses leading to degrees, mentioned above, a number of shorter courses are also offered. They are: *Chemistry and Assaying, Mining, Surveying and Electricity.* They have been planned for the benefit of those who, for various legitimate reasons, are unable to take the regular four-year courses.

The course in *Assaying and Chemistry* requires two years' work, although mature students, who have already some knowledge of chemistry, may complete it in one year. For description see page 44.

The purpose of the course in *Surveying* is to develop competent land and mining surveyors and fair draftsmen. The essentials of it are a thorough knowledge of algebra, trigonometry, surveying, field practice, and drawing. One school year and the first term of a second, will be required for the completion of this course.

A two-year course in *Mining* is offered to students, especially such as have had some practical experience, who may wish to fit themselves for holding important positions about mines or in ore dressing plants, but who are unable, on account of the lack of preparation or of time, to take the full course in Mining Enginering. Besides mathematics this course includes general chemistry, assaying, mineralogy, geology, mining, surveying, and English.

A course in *Electricity* is offered to furnish the student with the theory of electricity, and acquaint him with its application in the arts. This subject is of great importance to every engineer, especially to the mining engineer, since electricity has become such an important factor in mining operations.

See remarks on special students, page 26, and outline of special courses beginning page 44.

SUMMER SCHOOL.

In order to provide an opportunity for students to make up deficiencies, certain laboratories are open for six weeks during the summer. Applicants for admission to advanced standing are frequently deficient in mineralogy and advanced chemistry; by attending the summer school they can generally arrange a more satisfactory schedule for the college year.

All of the courses will be given in the laboratories at Rolla. The summers at Rolla are delightful, Rolla being located in the Ozarks at an elevation of eleven hundred forty feet. Many visitors spend the summer annually at Rolla because of the pleasant weather of the months of June and July.

Courses Offered in 1909.

Assaying.—This course is a duplicate of the regular course in fire assaying, given during the regular college year. A complete description of this course is given under Metallurgy and Ore Dressing on page 71. Students taking the summer course in assaying who are candidates for degrees will be given credit for both lectures and laboratory work.

Twenty-four hours per week for six weeks.

Metallurgy Laboratory.—This course is a duplicate of Course M-13 as described on page 81. Full credit will be given for the work as required for the degree of Bachelor of Science in Mining Engineering in the laboratory work and in Metallurgy Conference, M-12, as described on page 81 under Metallurgy and Ore Dressing.

Fifteen hours per week for six weeks.

VIEW ON THE CAMPUS

Qualitative Chemical Analysis.—The work in qualitative analysis is a duplicate of Course 3 in Chemistry as described on page 53. Any student completing the entire summer course will be given credit for the qualitative lectures and two terms qualitative laboratory.

Twenty hours per week for six weeks.

Quantitative Chemical Analysis.—This is a duplicate of Course 4 described under Chemistry on page 53. Students who finish this summer course will be credited for two hours quantitative lectures and for all of the quantitative laboratory required for mining engineers.

Thirty hours per week for six weeks.

Mineralogy Laboratory.—The student who completes the summer work in mineralogy will be given credit for two of the three terms' work in crystallography and mineralogy required for the degree of Bachelor of Science in Mining Engineering. This course is described as Course 1 under Geology and Mineralogy on page 72.

Twenty-four hours per week for six weeks.

Mining.—This course includes lectures on prospecting, drilling, blasting, boring, tunneling, shaft-sinking, mining methods, supporting excavations, and mine timbering. The student who completes the summer course in mining will be given credit for elementary mining described on page 68 under Mining Engineering as Course 1, and also Course 3 in Mining Engineering.

Six lectures per week for six weeks.

Equipment.

The laboratories of the school are thoroughly equipped in every particular and the equipment used in the regular course is open to summer students. Detailed description of the equipment will be found under the description of laboratories in the several courses.

Fees.

For the summer school of 1909 every student who enrolls will be required to pay the registration and tuition fees and to make the contingent deposit. In addition each student will pay the regular laboratory fees for such courses as he elects.

Registration Fee	$ 5.00
Tuition Fee	5.00
Contingent Deposit	10.00
Assay Laboratory Fee	25.00
Qualitative Laboratory Fee	15.00
Quantitative Laboratory Fee	3.50
Mineralogy Laboratory Fee	6.00
Metallurgy Laboratory Fee	5.00

A special circular describing summer courses will be sent on request.

EXCURSIONS.

Required.

A.—At the close of the Sophomore year, three weeks of summer field work for practice in topography and lines of communication is required of students in Civil Engineering. This work is carried on in the vicinity of Rolla.

B.—At the opening of the school year, in September, one week's field work in Topography by all Juniors not taking A.

C.—At the close of the Junior year, students in Mining and Metallurgical Engineering make a three weeks' excursion to southeast Missouri, for practice in mine surveying and the study of field and economic geology, mining, and ore dressing.

D.—During the Senior year a one week's trip to southwest Missouri, particularly the Joplin district, for the study of ore deposits, mining methods, and ore dressing.

E.—Excursions by the Senior class to Steelville, Sligo, DeCamp, Meramec, Newburg, and Sullivan for the purpose of studying iron, copper, lead deposits, and methods of reduction. This excursion takes place during the latter part of the Senior year.

F.—An excursion by the Senior class to Herculaneum, St. Louis, Granite City, and the coal fields of Illinois. This excursion is during the latter part of the Senior year.

Voluntary.

In addition to the foregoing trips which are required in the various courses, a number of optional excursions can be made under the supervision of the members of the Faculty. These excursions are planned for students who have finished the work of the Junior year and may be made to the following mining districts:

1.—Southern Appalachian District where geology, mining, and metallurgy may be studied, particularly in the mining districts of Birmingham, Ala., and Ducktown, Tenn.

2.—Copper mining districts of the Southwest, particularly Bisbee, Ariz., and Cananea, Mexico.

3.—Lake Superior mining district including the copper and iron ranges of Michigan and the iron ranges of Minnesota.

4.—Metal mining districts of Colorado, Utah, and Montana.

COURSE I.—MINING ENGINEERING

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FRESHMAN YEAR.			
LECTURES AND RECITATIONS:			
College Algebra	5	0	0
Plane Trigonometry	0	5	0
Spherical Trigonometry Analytical Geometry	0	0	5
Descriptive Geometry	0	2	2
General Chemistry	5	5	4
English	5	5	5
Elementary Mining	2	0	0
Mineralogy	0	0	2
LABORATORY WORK:			
General Chemistry	3	3	3
Drawing, Mechanical	6	6	6
Descriptive Geometry Drawing	0	3	3
Shop Practice	6	6	0
Mineralogy Laboratory	0	0	6
SOPHOMORE YEAR.			
LECTURES AND RECITATIONS:			
Analytical Geometry Differential Calculus	5	0	0
Spanish, German, or French	5	5	5
Advanced English	1	1	1
Integral Calculus	0	5	0
Differential Equations	0	0	5
Mineralogy	2	0	0
Lithology	0	2	0
Plane Surveying	3	0	0
Mine Surveying	2	0	0
Mining	0	2	3
Elementary Mechanics	0	2	0
General Physics	0	0	5
Qualitative Analysis	0	2	0
LABORATORY WORK:			
Forge Shop or Machine Drawing	6	6	6
Mineralogy	6	6	0
Lithology	0	3	0
Surveying Field Practice	6	0	0
Qualitative Analysis	0	6	6
Physics	0	0	6
Topography, one week between the Sophomore and Junior Years.			

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
JUNIOR YEAR			
LECTURES AND RECITATIONS:			
General Physics	5	0	0
Thermodynamics	0	5	0
Mechanics of Engineering	5	0	0
Mechanics of Materials	0	5	0
Hydraulics	0	0	5
General Geology	5	3	5
Quantitative Analysis	2	0	0
Assaying	2	0	0
Metallurgy	0	3	3
Masonry	0	2	0
Lines of Communication	0	0	2
Elements of Ore Dressing	0	0	3
LABORATORY WORK:			
Physics	6	0	0
Steam	0	3	0
Assaying	6	6	0
Quantitative Analysis	6	9	0
General Geology	0	3	6
Drawing and Graphics	0	0	6
Lines of Communication	0	0	3
Hydraulics	0	0	3
Excursion to Southeast Missouri.			
SENIOR YEAR			
LECTURES AND RECITATIONS:			
Ore Dressing	4	4	4
Ore Dressing Memoirs	0	0	1
Mining Law and Contracts	2	0	0
Mine Management	0	0	2
Metallurgy	4	4	4
Metallurgy Conference	0	1	0
Economic Geology	3	3	5
Dynamo Machinery	3	0	0
Alternating Current Machinery	0	5	0
Electrical Transmission	0	0	3
Compressed Air	0	2	0
Frame Structures	2	0	0
Hydraulic Motors and Pumps	0	0	1
LABORATORY WORK:			
Ore Dressing	6	0	0
Ore Dressing Problems	0	3	3
Graphics	3	0	0
Dynamo Machinery	6	0	0
Alternating Current Machinery	0	6	0
Electrical Problems	0	0	3
Metallurgy	0	7	0
Compressed Air	0	3	0
Thesis	0	0	6
Senior Trips.			

MINING GEOLOGY OPTION

SENIOR YEAR

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
LECTURES AND RECITATIONS:			
Economic Geology	3	3	5
Petrography	3	3	2
Geology of the United States	3	0	0
Structural and Metamorphic Geology	0	0	3
Paleontology or Metallurgy	4	4	0
Historical Geology or Metallurgy	0	0	4
Geological Conference	0	2	0
Ore Dressing	4	0	0
Mining Law and Contracts	2	0	0
Methods of Prospecting and Mine Development	0	3	0
Mine Management	0	0	2
Elective Geology	0	0	3
LABORATORY WORK:			
Geology	3	6	6
Petrography	9	6	6
Ore Dressing	6	0	0
Paleontology or Metallurgy	0	6	0
Thesis	0	0	6
Senior Trips			

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MACHINE SHOP

MINING MACHINERY OPTION

SENIOR YEAR

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
LECTURES AND RECITATIONS:			
Ore Dressing	4	4	4
Ore Dressing Memoirs	0	0	1
Mining Machinery	0	4	5
Dynamo Machinery	3	0	0
Alternating Current Machinery	0	5	0
Electrical Transmission	0	0	3
Compressed Air	0	2	0
Hydraulic Motors and Pumps	0	0	1
Mine Management	0	0	2
Mining Law and Contracts	2	0	0
Economic Geology	3	0	0
Metallurgy	4	4	0
Metallurgy Conference	0	1	0
Frame Structures	2	0	0
Cement and Concrete Structures	0	0	2
LABORATORY WORK:			
Mining Machinery	3	9	0
Mining Machinery Problems	0	0	6
Graphics	3	0	0
Dynamo Machinery	6	0	0
Alternating Current Machinery	0	6	0
Electrical Problems	0	0	3
Ore Dressing	6	0	0
Metallurgy	0	4	0
Compressed Air	0	3	0
Thesis	0	0	6
Senior Trips.			

ORE DRESSING OPTION

SENIOR YEAR

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
LECTURES AND RECITATIONS:			
Ore Dressing	4	4	4
Ore Dressing Memoirs	0	0	1
Mining Law and Contracts	2	0	0
Mine Management	0	0	2
Metallurgy	4	4	4
Metallurgy Conference	0	1	0
Economic Geology	3	3	5
Dynamo Machinery	3	0	0
Alternating Current Machinery	0	5	0
Electrical Transmission	0	0	3
Compressed Air	0	2	0
Frame Structures	2	0	0
Hydraulic Motors and Pumps	0	0	1
LABORATORY WORK:			
Ore Dressing	9	0	6
Ore Dressing Problems	0	3	3
Graphics	3	0	0
Dynamo Machinery	6	0	0
Alternating Current Machinery	0	6	0
Electrical Problems	0	0	3
Metallurgy	0	7	0
Compressed Air	0	3	0
Thesis	0	0	6
Senior Trips.			

COURSE II.—METALLURGY

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FRESHMAN YEAR.			
LECTURES AND RECITATIONS:			
College Algebra	5	0	0
Plane Trigonometry	0	5	0
Spherical Trigonometry Analytical Geometry	0	0	5
General Chemistry	5	5	4
English	5	5	5
Descriptive Geometry	0	2	2
Elementary Mining	2	0	0
Mineralogy	0	0	2
Qualitative Analysis	0	2	0
LABORATORY WORK:			
General Chemistry	9	0	0
Mechanical Drawing	6	6	6
Qualitative Analysis	0	9	6
Mineralogy	0	0	6
Descriptive Geometry	0	3	3
SOPHOMORE YEAR.			
LECTURES AND RECITATIONS:			
Analytical Geometry Differential Calculus	5	0	0
Integral Calculus	0	5	0
Differential Equations	0	0	5
German, French, or Spanish	5	5	5
Elementary Mechanics	0	2	0
Advanced English	1	1	1
General Physics	0	0	5
Lithology	0	2	0
Quantitative Analysis	2	2	2
Surveying, Plane	3	0	0
Mineralogy	2	0	0
LABORATORY WORK:			
Field Practice	6	0	0
Quantitative Analysis	6	9	12
Mineralogy	6	6	0
Lithology	0	3	0
Physics	0	0	6

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
JUNIOR YEAR.			
LECTURES AND RECITATIONS:			
Assaying	2	0	0
General Geology	5	3	5
General Physics	5	0	0
Mechanics of Engineering	5	0	0
Chemical Memoirs	2	0	0
Electro-Chemistry	0	2	3
Mechanics of Materials	0	5	0
Hydraulics	0	0	5
Elements of Ore Dressing	0	0	3
Metallurgy	0	3	3
Physical Chemistry	0	2	0
Thermodynamics	0	5	0
LABORATORY WORK:			
Assaying	6	6	0
Geology	0	3	0
Field Geology	0	0	6
Physics	6	0	0
Quantitative Analysis	6	0	0
Physical Chemistry	0	3	0
Electro-Chemistry	0	3	6
Metallurgy	0	0	3
Hydraulics	0	0	3
Steam	0	3	0
Excursion to southeast Missouri.			
SENIOR YEAR			
LECTURES AND RECITATIONS:			
Alloys	2	0	0
Alternating Current Machinery	0	5	0
Dynamo Machinery	3	0	0
Electro-Metallurgy	2	0	0
Contracts	2	0	0
Metallurgical Problems	1	0	1
Metallurgy	4	4	4
Ore Dressing	4	4	4
Compressed Air	0	2	0
Metallurgy Conference	0	1	0
Metallurgical Organization	0	3	0
Electrical Transmission	0	0	3
Memoirs, Chemical and Metallurgical	0	0	1
Hydraulic Motors and Pumps	0	0	1
Technical Chemical Analysis	0	0	1
LABORATORY WORK:			
Metallurgy and Electro Metallurgy	6	0	0
Ore Dressing	9	0	6
Dynamo Machinery	6	0	0
Compressed Air	0	3	0
Alternating Currents	0	6	0
Metallurgy	0	7	0
Metallography	0	3	0
Electrical Problems	0	0	3
Technical Analysis (Chemical)	0	0	3
Thesis	0	0	6
Senior Trips.			

COURSE III.—CIVIL ENGINEERING

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FRESHMAN YEAR.			
LECTURES AND RECITATIONS:			
College Algebra	5	0	0
General Chemistry	5	5	4
English	5	5	5
Descriptive Geometry	0	2	2
Elementary Mining	2	0	0
Plane Trigonometry	0	5	0
Spherical Trigonometry	0	0	5
Analytical Geometry			
Mineralogy	0	0	2
LABORATORY WORK:			
General Chemistry	3	3	3
Descriptive Geometry Drawing	0	3	3
Mechanical Drawing	6	6	6
Shop Practice	6	6	0
Mineralogy	0	0	6
SOPHOMORE YEAR.			
LECTURES AND RECITATIONS:			
Analytical Geometry	5	0	0
Differential Calculus			
Integral Calculus	0	5	0
Differential Equations	0	0	5
Advanced English	1	1	1
Spanish, German, or French	5	5	5
Elementary Mechanics	0	2	0
Plane Surveying	3	0	0
Mine Surveying	2	0	0
General Physics	0	0	5
Lines of Communication	0	0	2
Geodesy	0	3	0
LABORATORY WORK:			
Field Practice	9	0	9
Forge Shop or Machine Drawing	6	6	0
Geodesy and Computations	0	9	0
Physics	0	0	6
Topography, one week.			

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
JUNIOR YEAR			
LECTURES AND RECITATIONS:			
Astronomy	0	0	2
General Geology	5	3	5
Hydraulics	0	0	5
Mechanics of Engineering	5	0	0
Masonry	0	2	0
Mechanics of Materials	0	5	0
Metallurgy of Iron and Steel	0	0	3
General Physics	5	0	0
Lines of Communication	3	0	0
Thermodynamics	0	5	0
Roads and Pavements	0	0	2
Graphics	0	2	0
LABORATORY WORK:			
Drawing and Graphics	0	0	6
Hydraulics	0	0	3
General Geology	0	3	6
Field Practice	9	0	0
Engineering Laboratory and Graphics	0	12	0
Physics	6	0	0
Steam	0	3	0
SENIOR YEAR			
LECTURES AND RECITATIONS:........			
Alternating Current Machinery	0	5	0
Bridges (Higher Structures)	0	5	0
Compressed Air	0	2	0
Dynamo Machinery	3	0	0
Economic Geology	3	0	0
Electrical Transmission	0	0	3
Estimates and Bidding	0	0	2
Framed Structures	2	0	0
Hydraulic Motors and Pumps	0	0	1
Irrigation	0	0	3
Masonry Design and Concrete Steel	0	0	5
Mining Law and Contracts	2	0	0
River and Harbor Improvements	0	0	2
Railroad Economics	3	0	0
Sanitary Engineering	0	5	0
Water Supply	5	0	0
LABORATORY WORK:			
Dynamo Machinery	6	0	0
Alternating Current Machinery	0	5	0
Compressed Air	0	3	0
Designing	0	6	6
Graphics and Engineering Designs	9	0	0
Electrical Problems	0	0	3
Thesis	0	0	6

COURSE IV.—GENERAL SCIENCE

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FRESHMAN YEAR			
LECTURES AND RECITATIONS:			
College Algebra	5	0	0
General Chemistry	5	5	4
English	5	5	5
Elementary Mining	2	0	0
German	0	4	4
Mineralogy	0	0	2
Plane Trigonometry	0	5	0
Spherical Trigonometry	0	0	5
Analytical Geometry			
LABORATORY WORK:			
Drawing	6	6	6
General Chemistry	3	3	3
Mineralogy	0	0	6
Elective	6	6	0
SOPHOMORE YEAR.			
LECTURES AND RECITATIONS:			
German	5	5	5
English	5	5	5
Elementary Mechanics	0	2	0
Qualitative Analysis	0	2	0
Mineralogy	2	0	0
Elective	6	4	8
LABORATORY WORK·			
Qualitative Analysis	0	6	6
Mineralogy	6	6	0
Physics	0	0	6
Elective	9	6	3
JUNIOR YEAR.			
LECTURES AND RECITATIONS:			
French or Spanish	5	5	5
General Geology	5	3	5
General Physics	5	0	0
Elective	3	10	8
LABORATORY WORK:			
General Geology	0	3	6
General Physics	6	0	0
Elective	9	12	9

SENIOR YEAR

All elective.

The selection of studies is subject to the approval of the Faculty.

Electives after the Sophomore year must be along one of the two lines: Physics and Mathematics, or Chemistry and Geology. Twenty-three hours recitation, or eighteen hours recitation and five afternoons laboratory work a week, constitute a course.

SPECIAL COURSE IN MINING AND ASSAYING

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FIRST YEAR			
LECTURES AND RECITATIONS:			
College Algebra	5	0	0
Plane Trigonometry	0	5	0
Spherical Trigonometry	0	0	5
Analytical Geometry			
English	5	5	5
General Chemistry	5	5	4
Qualitative Analysis	0	2	0
Elementary Mining	2	0	0
Mineralogy	0	0	2
Elements of Ore Dressing	0	0	3
LABORATORY WORK:			
General Chemistry	9	0	0
Qualitative Analysis	0	9	9
Drawing, Mechanical	6	6	6
Mineralogy	0	0	6
SECOND YEAR			
LECTURES AND RECITATIONS:			
Ore Dressing	4	3	0
General Geology	5	3	5
Mining	0	2	3
Assaying	2	0	0
Plane Surveying	3	0	0
Mine Surveying	2	0	0
Mineralogy	2	0	0
Lithology	0	2	0
Quantitative Analysis	2	0	0
Lines of Communication	0	0	2
LABORATORY WORK:			
Surveying, Field Practice	6	0	0
Ore Dressing	6	0	3
Mineralogy	6	6	0
Lithology	0	3	0
General Geology	0	3	6
Assaying	0	9	0
Quantitative Analysis	6	6	6
Lines of Communication	0	0	3

SPECIAL COURSE IN ELECTRICITY

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FIRST YEAR.			
Lectures and Recitations:			
College Algebra	5	0	0
Plane Trigonometry	0	5	0
Spherical Trigonometry	0	0	5
Analytical Geometry			
English	5	5	5
General Chemistry	5	5	4
Electricity and Magnetism	0	3	0
Laboratory Work:			
General Chemistry	3	3	3
Drawing, Mechanical	6	6	6
Shop Practice	6	6	0
Physics	0	3	6
SECOND YEAR.			
Lectures and Recitations:			
Analytical Geometry	5	0	0
Differential Calculus			
Integral Calculus	0	5	0
Differential Equations	0	0	5
Elementary Mechanics	0	2	0
General Physics	5	0	5
Dynamo Machinery	3	0	0
Thermodynamics	0	5	0
Elective	3	3	6
Laboratory Work:			
Physics	9	9	9
Steam	0	3	0
Elective	6	3	6

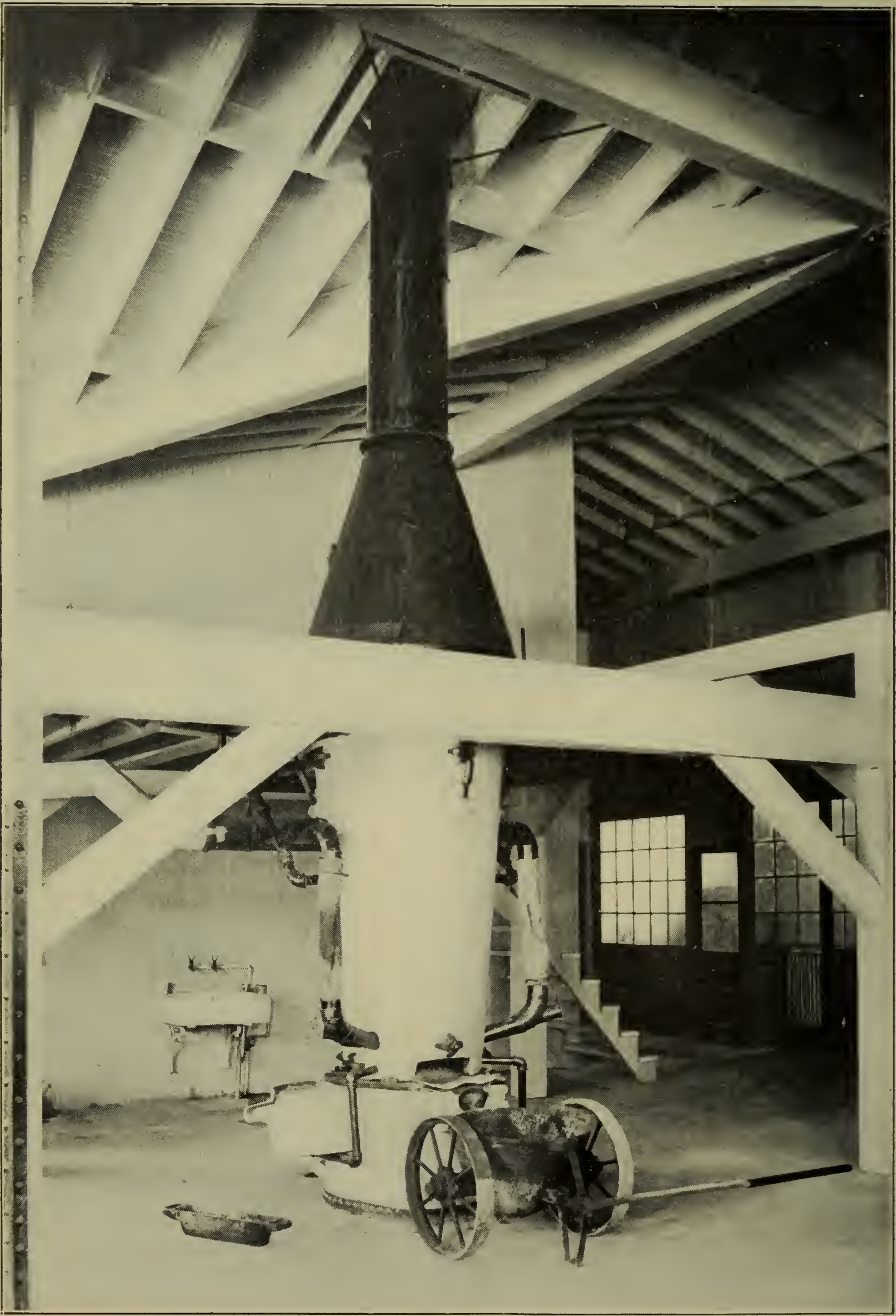
SPECIAL COURSE IN SURVEYING

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FIRST YEAR.			
LECTURES AND RECITATIONS:			
College Algebra	5	0	0
Plane Trigonometry	0	5	0
Spherical Trigonometry Analytical Geometry	0	0	5
English	5	5	5
Elective	5	5	5
LABORATORY WORK:			
Drawing	6	6	6
Field Practice	0	0	6
Elective	9	9	3

SECOND YEAR.

LECTURES AND RECITATIONS:

Surveying	3 hours per week.
Elective	12 hours per week.
Field Practice	9 hours per week.
Drawing	6 hours per week.



WATER JACKET BLAST FURNACE

GRADUATE COURSES.

The School of Mines offers graduate work in Mining Engineering, Metallurgy, Ore Dressing, Geology, Economic Geology, Petrography, and Advanced Chemistry. The attention of graduates of engineering schools and of mining schools is directed to the following courses:

Mine Management
Mining Machinery
Mining Machinery Laboratory
Mining Machinery Problems
Mining Law and Contracts
Economic Geology
Geology of the United States
Structural and Metamorphic Geology
Paleontology
Historical Geology
Petrography
Petrography Laboratory
Cement and Concrete Structures
Compressed Air
Engineering Designs
Ore Dressing Laboratory
Ore Dressing Problems
Ore Supply
Metallurgy Organization
Metallography
Constitution of Alloys
Metallurgical Problems
Metallurgical Plant
Metallurgical Plant Design
Cyaniding
Electro-Metallurgy
Electro-Metallurgy Laboratory
Metallurgical Research
Electro-Chemistry
Slag Analysis
Metallurgical Analysis
Technical Analysis
Physical Chemistry
Theoretical Chemistry
Advanced Physico-Chemical Laboratory

GRADUATE COURSE FOR ENGINEERS*

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FIRST YEAR.			
Lectures and Recitations:			
Mine Surveying	2	0	0
Geology	5	3	5
Mineralogy	3	0	0
Lithology	0	2	0
Qualitative Analysis	0	2	0
Assaying	2	0	0
Ore Dressing	0	0	3
Mining	0	2	3
Metallurgy	0	3	3
Elective	6	6	4
Laboratory Work:			
Mineralogy	12	6	0
Lithology	0	3	0
Geology	0	3	6
Qualitative Analysis	0	6	6
Assaying	0	0	9
Elective	3	3	0
SECOND YEAR.			
Lectures and Recitations:			
Compressed Air	0	2	0
Quantitative Analysis	2	0	0
Economic Geology	3	3	5
Metallurgy	4	4	4
Metallurgy Conference	0	1	0
Ore Dressing	4	3	0
Ore Dressing Memoirs	0	0	1
Mining Law and Contracts	2	0	0
Mine Management	0	0	2
Elective	3	5	5
Laboratory Work:			
Quantitative Analysis	6	9	0
Ore Dressing	6	0	3
Compressed Air	0	3	0
Geology	3	0	3
Metallography	0	3	0
Mining Problems	0	0	3
Thesis	0	0	6
Elective	3	3	3

*This two-year course is planned for graduates in Civil, Electrical, or Mechanical Engineering, who desire to work along mining lines. The degree, Mining Engineer, will be conferred on students who have received the Bachelor of Science Degree in Engineering, and who complete the two-year course as outlined.

MATHEMATICS.

PROFESSOR DEAN; ASSISTANT PROFESSOR GARRETT,
MR. FORRESTER.

While the utility of mathematical study as a mental discipline is duly recognized, the ultimate intention of the student is kept in mind, and the matter and the method of the courses are adjusted to meet the demands of subsequent studies in pure and applied science.

Students who bring credits from other colleges will be allowed to enter with advanced standing only when the courses can be shown to be equivalent to those given here, and then only conditionally. Those who fail to do creditable work in the courses undertaken, will be required to drop such courses and take up more elementary work.

1. *College Algebra.*—The time allotted for this course being very short, only such work is given as is found absolutely necessary to prepare for subsequent studies.

Freshman year, first term, five hours per week.

Texts: Hawkes, *Advanced Algebra.*
Gibson, *Graphs.*

2. *Plane Trigonometry.*—This subject is the most important in the mathematical equipment of the engineer. The student is drilled, not only in the solution of triangles and other geometrical problems, but in the application of the trigonometric functions to analysis and in shortening computations.

Freshman year, second term, five hours per week.

Text: Taylor and Puryear, *Trigonometry.*

3. *Spherical Trigonometry.*—This course is limited to practical applications in astronomy, geodesy, and mine surveying.

Freshman year, first three weeks of third term, five hours per week.

Text: Taylor and Puryear, *Trigonometry.*

4. *Analytical Geometry.*—This Course includes the study of the straight line, the circle, and special forms of the equations of the conic sections.

Freshman year, third term after Course 3, five hours per week. Text: Ashton, *Analytic Geometry.*

5. *Descriptive Geometry.*—The usual text-book work is reinforced with daily black-board exercises in presenting the projections of familiar objects, intersections of plane and curved surfaces, sections, developments, and shades and shadows. The afternoons in the drawing room are spent in solving in neat form the more elaborate exercises.

Freshman year, second and third terms, two recitations per week, and three hours at the drawing board.

Text: Faunce, *Descriptive Geometry.*

6. *Analytical Geometry.*—This is a continuation of Course 4 and includes the study of the general equation of the second degree, general theorems on conic sections, and the higher plane curves such as the catenary, cycloid, and spirals.

Sophomore year, first four weeks of the first term, five hours per week.

Texts: Ashton, *Analytical Geometry.*
Dean, *Manuscript Notes.*

7. *Differential Calculus.*—The student is given a thorough drill in the derivation of formulae, and application of derivatives and differentials, in the solution of problems in maxima and minima, curve tracing, rates, velocities and accelerations, and expansion of functions.

Sophomore year, first term, five hours per week, following Course 6.

Texts: Osborn, *Calculus.*
Dean, *Manuscript Notes.*

8. *Integral Calculus.*—Attention is paid largely to attaining as much skill as possible in integration of forms occurring in mechanics and physics. As the student acquires his fund of knowledge and experience, he is drilled in evaluating areas, lengths of curves, moments of inertia, and centres of gravity.

Sophomore year, second term, five hours per week.

Texts: Osborn, *Calculus.*
Dean, *Manuscript Notes.*

9. *Differential Equations.*—This course is a continuation of Course 8, taking up more difficult problems, and higher developments of the subject, dynamics of a particle, theory of attraction; and thermodynamics of perfect gases.

Sophomore year, third term, five hours per week.

Texts: Campbell, *Differential Equations;*
Dean, *Manuscript Notes.*

10. *Mechanics of Engineering.*—It is the aim in this course to develop the essential principles of mechanics and to train the student to be proficient in applying them to practical, rather than to theoretical, problems. A large number of problems are solved, which, so far as possible, are selected from machines or structures with which the student is already familiar, or from the study of which he is to make up subsequently.

Junior year, first term, five hours per week.

Text: Maurer, *Technical Mechanics.*

11. *Mechanics of Materials.*—This course includes a study of the theory of stress, strain and elasticity and its application to the design of members of machines and structures; a discussion of the properties of the materials of engineering construction.

Junior year, second term, five hours per week.

Text: Slocum and Hancock, *Strength of Materials.*

Elective Work.

Students in the General Science Course who elect work in pure mathematics will confer with the head of the department, who will arrange work according to the needs, tastes, and aptitudes of the applicants.

The following courses are offered to students who have passed all the required work in mathematics, mechanics, and general physics.

1. Dynamics of Particles and Rigid Bodies.
2. Hydrodynamics.
3. Mathematical Theory of Elasticity.
4. Newtonian Potential Function.

5. Harmonic Functions.
6. Theory of Probability and Method of Least Squares.
7. Differential Equations of Mechanics and Physics.
8. Mechanics of Hoisting Machinery.

CHEMISTRY.

Professor Gottschalk, Assistant Professor Thompson, Mr. Hynes, Mr. Barrett, Mr. Riede, Mr. Lane.

Equipment.

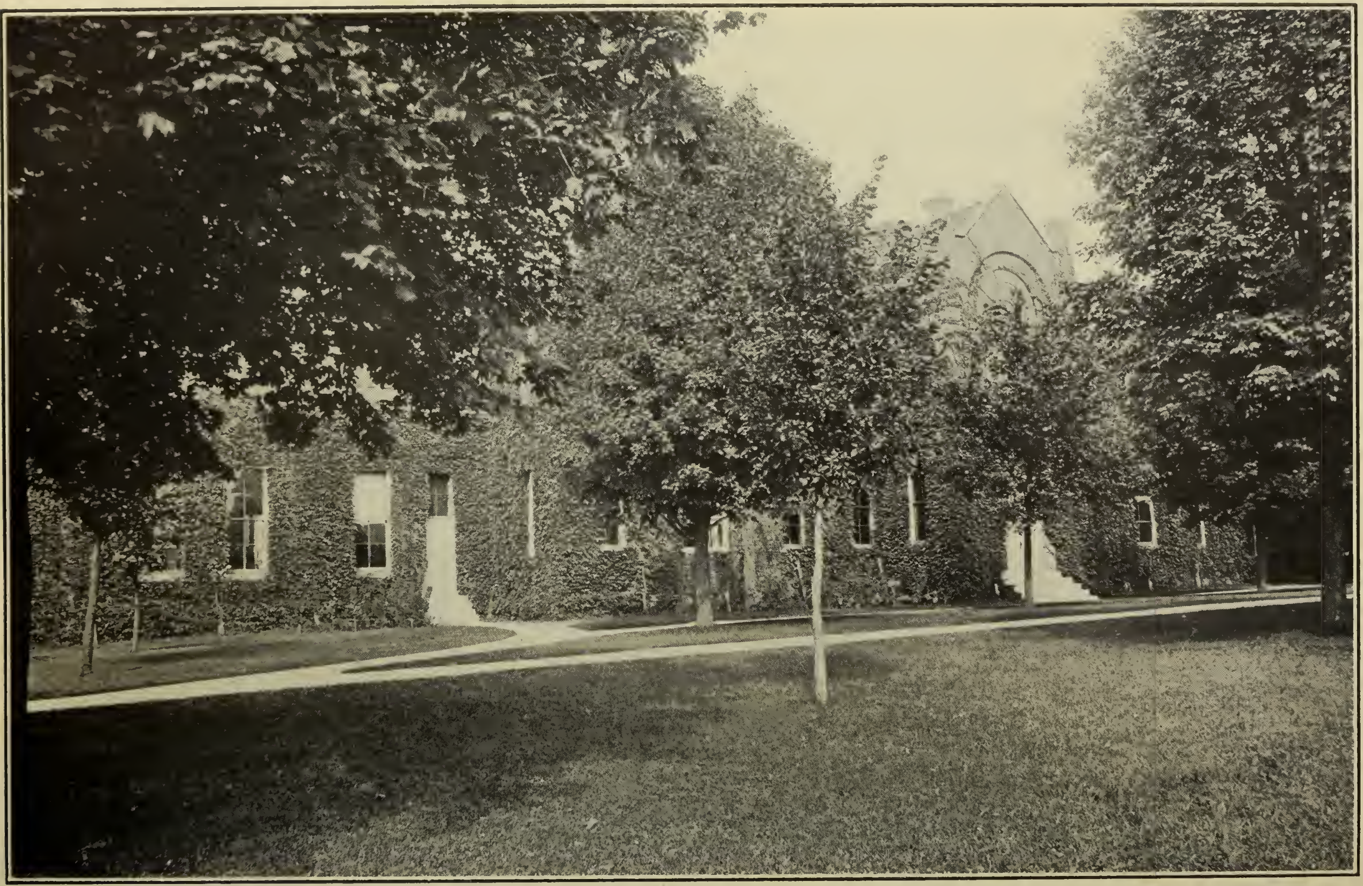
One entire building is given to chemistry. The main chemical lecture room occupies the entire south wing of the building and contains a long lecture desk with gas and water connections for lecture experiments and a large glass hood and side desks fit it for demonstration purposes for large classes. The general chemistry laboratories contain the lockers and desks for one hundred students.

The qualitative analysis laboratory provides desk space for forty students working at one time. A long line of hoods extends along two walls of the room. Air blast is provided and the room is well ventilated by means of a blower. The entire second floor of the building is used for quantitative analysis. The main laboratory will accomodate fifty-two students at one time. Gas and water are supplied conveniently and compressed air furnishes blast for thirteen blast lamps. The balance rooms on the north side of the building contain nineteen first-class balances.

There are several private and research laboratories on both floors.

Courses.

1. *General Chemistry.*—This course is a comprehensive study of the general principles of chemistry and of the more important elements. Special attention is paid to the chemistry of the metals. The Periodic law is followed throughout.



CHEMICAL HALL

The lectures are fully illustrated; the class is divided into several smaller sections for recitations.

Freshman year, first and second terms, five hours per week; third term, four hours per week.

Text: Gooch and Walker, *Outlines of Inorganic Chemistry.*

2. *General Chemistry Laboratory.*—The laboratory work accompanying general chemistry consists of experiments which are largely quantitative, and which are intended to teach stoichiometrical relations from the first.

Freshman year, one afternoon per week throughout the year, Civil Engineering and Mining Engineering Courses; first term, three afternoons per week, Metallurgy Course, and Special Courses in Mining, Surveying, and Assaying.

3. *Qualitative Analysis.*—This course includes lectures and laboratory work; the laboratory work includes the tests and separation of the more common metallic elements; analysis of solutions containing phosphates, of alkaline solutions, of insoluble substances, of alloys, of natural products, and of slags; also blow-pipe analysis.

Lectures, Sophomore year, second term, two hours per week, Mining Engineering and General Science Courses; Freshman year, second term, two hours per week, Metallurgy Course, and Special Courses in Mining and Assaying.

Laboratory work, Sophomore year, second and third terms, two afternoons per week, Mining Engineering, and General Science Courses; Freshman year, third term, two afternoons per week, Metallurgy Course; first year, second and third terms, three afternoons per week, Special Courses in Mining and Assaying.

The same course is given in the summer school.

Text: Treadwell and Hall, *Qualitative Analysis.*

4. *Quantitative Analysis* — Introductory Course. — This work begins with a study of the balance; this is followed by accurate gravimetric analysis, first on pure soluble salts, then on natural products; then by accurate volumetric analysis (acidimetry, alkalimetry, iron by the permanganate method).

As samples of technical work, the wet assays as practiced in the West, are studied during the latter half of the course.

Lectures, Junior year, first term, two hours per week, Mining Engineering Course; Sophomore year, first term, two hours per week, Metallurgy Course and Special Course in Mining and Assaying.

Laboratory work, Junior year, first term, two afternoons per week; second term, three afternoons per week, Mining Engineering Course; Sophomore year, first term, two afternoons per week; second term, three afternoons per week, Metallurgy Course; second year, first term, two afternoons per week; second term, three afternoons per week, Special Courses in Mining, Chemistry, and Assaying.

The same course is given in the summer school.

Text: Miller, *Quantitative Analysis for Mining Engineers.*

5. *Quantitative Analysis Lectures.*—This lecture course comprises a complete exposition of the general methods and details of manipulation of analysis, theory of instruments used, general chemical theory not included in Freshman chemistry, and the discussion of the sources of error, including testing, purification, and preparation of reagents.

Sophomore year, second and third terms, two hours per week, Metallurgy Course.

6. *Quantitative Analysis* (*Advanced*).—This course is planned to train the student in general methods of technical analysis.

Laboratory work, second year, third term, two afternoons per week, Special Course in Chemistry, Mining and Assaying.

7. *Slag Analysis.*—This course presents the methods for complete analysis of slags of various kinds.

Laboratory work, Sophomore year, third term, four afternoons per week, Metallurgy Course.

8. *Metallurgical Analysis.*—Advanced quantitative analysis in its application to metallurgy and metallurgical processes is presented in the laboratory.

Laboratory work, Junior year, first term, two afternoons per week, Metallurgy Course.

9. *Technical Analysis.*—This is an advanced and applied course in quantitative analysis.

Senior year, third term, one hour per week, Metallurgy Course.

Laboratory work, Senior year, third term, one afternoon per week, Metallurgy Course.

10. *Chemical Memoirs.*—Carefully prepared abstracts of current articles or of special subjects are prepared by the students for this course.

Reports, Senior year, first term, one hour per week, Metallurgy Course.

11. *Electro-Chemistry.*—This course includes a theoretical introduction of the study of electro-chemistry and is followed by applications of principles.

Junior year, second term, two hours per week; third term, three hours per week, Metallurgy Course.

Laboratory work, Junior year, second term, one afternoon per week; third term, two afternoons per week, Metallurgy Course.

12. *Physical Chemistry.*—This is a short course designed mainly as an introduction to the various kinds of chemical equilibria encountered in metallurgical practice.

Junior year, second term, two hours per week, Metallurgy Course.

Laboratory work, Junior year, second term, one afternoon per week, Metallurgy Course.

Graduate Course.

13. *Theoretical Chemistry.*—The application of theoretical chemistry to fundamental metallurgical principles are assuming such prominence and leading to such important results that a knowledge of this subject is indispensable to the metallurgical engineer who desires to keep pace with the de-

velopments in his field. To meet this demand a course for graduate students is offered, presenting the subject of chemical equilibria from the thermodynamic point of view, including a consideration of the technical applications made by Nernst, Le Chatelier, Haber, von Jüptner, and others. The student is expected to do considerable reading of original articles in English, German, and French scientific journals and books.

Graduate Course, first and second terms, two hours per week.

14.—*Advanced Physico-Chemical Laboratory.*—This is an advanced course to accompany the lectures in Theoretical Chemistry, and includes the study and measurements of typical chemical equilibria, either as a repetition of classical researches in this field or preferably on original problems. The equipment for this work includes measuring instruments of the most approved types for high temperature, electro-thermic and physico-chemical work, and special apparatus built in the school shops.

Graduate Course, first and second terms, two afternoons per week.

PHYSICS.

Professor McRae, Mr. Pollard.

Equipment.

The lecture room and laboratories for Physics and Electricity are in Norwood Hall. The lecture room will seat one hundred students and is provided with water, gas, and electric connections for conveniences in lecture demonstrations and experiments.

The physical laboratory is on the ground, or basement, floor. There are two large laboratories, one equipped for general physical measurements in mechanics, sound, and heat, and one equipped for electric measurements. There is a battery room equipped with both primary and secondary batteries connected by wires with the various laboratories and lecture room; a constant-temperature room with double walls and air space insulation; a commodious dark-room with blackened walls for spectrometric and photometric measurements, and a special laboratory for research work.

The equipment includes a Rowland electro-dynamometer with shunts and resistances; a Leeds & Northrup decade wheatstone bridge; a Queen & Co. post-office pattern wheatstone bridge; two portable testing sets; various wheatstone bridges and resistance boxes; standards of resistance inductance and capacity; a Lummer-Brodhun photometer; a Gaertner dividing engine, with linear and circular attachments; a Threlfall micromanometer; a Duddell thermo galvanometer; various tangent mirror and D'Arsonval galvanometers; a Parr coal calorimeter; a wireless telegraph demonstration set; a ten-inch induction coil; Crooke's tubes; X-ray tubes; Toepler Holtz machine; a Schmidt & Haensch spectrometer; a Rowland diffraction grating; photographs of Rowland's normal solar spectrum; Crosby, and Schaeffer and Budenberg steam and gas engine indicators; Amsler planimeters; tachometers and speed counters; various balances; micrometers, calipers, together with apparatus for illustrating the principles of physics.

The dynamo laboratory contains an assortment of direct-current generators and motors, a General Electric double-current generator for direct current and alternating current work, a single and a three-phase generator, an induction motor, a rotary transformer, stationary transformers, three-phase to two-phase transformers and a Cooper-Hewitt mercury vapor converter with testing instruments, which include a Weston laboratory standard volt-meter, with multipliers; a Weston laboratory standard milli-voltmeter, with shunts; a Kelvin electrostatic voltmeter; Weston portable direct-current ammeters; Weston portable direct-current and alternating-current voltmeter; Weston and Thomson portable watt-meters; Thomson alternating-current voltmeters; electro-dynamometers; a Grassott fluxmeter; inductance coils; and condensers.

The power-plant also is used for experimental purposes and comprises a strictly modern and thoroughly equipped laboratory. The machinery available for testing purposes includes three 130-h. p. Heine safety boilers. The steam engines include a 75-h. p. Ideal engine, a 35-h. p. Brownell engine, and a 7-h. p. Davis & Rankin vertical engine. A 15-h. p. Otto gas engine may be belted to electric generators or used for experimental purposes. The pneumatic equipment includes a Laidlaw-Dunn-Gordon air-compressor, a Rand Imperial type air-compressor, a 72-in. ventilating fan, a 36-in. ventilating fan, and a 60-in. Buffalo forge blower. There are six pumps of three different patterns which can be used for power or experimental purposes. The electric generators include a 50-kw. Westinghouse 220-volt direct-current generator, a 3½-kw., 120-volt generator, a 7½-kw. General Electric direct and alternating-current generator, a 2-kw. three-phase Westinghouse generator, and a 1-kw. Westinghouse single-phase generator.

The various electrical motors used for power purposes in the shops and laboratories are available for testing in addition to the machinery in the dynamo laboratory. The total electrical equipment includes thirty-five motors varying in size from ½-h. p. to 30-h. p., with the aggregate rating of 150-h. p.

Courses.

1. *Elementary Mechanics.*—This subject includes the study of the simple machines and the fundamental principles of mechanics and hydrostatics. Lectures are illustrated by experiments and recitations.

Sophomores, second term, two hours per week.

Text: Merriman, *Elements of Mechanics.*

2. *Electricity and Magnetism.*—This course is designed as an introduction of the study of electricity and magnetism.

Lectures and recitations, second term, three hours per week.

Text: S. P. Thompson, *Lessons in Electricity and Magnetism.*

3. *Laboratory Work in Electricity and Magnetism.*—Three afternoons per week throughout the year.

4a. *General Physics.*—The work in general physics begins with the study of kinematics, statics, kinetics, and the mechanics of fluids. The first term's work concludes with the study of heat, including an introduction of thermodynamics. 'Particular attention is paid to harmonic motion as the basis for the study of such subjects as sound, light, and alternating currents of electricity.

Sophomore year, third term, five hours per week.

Text: Watson, *General Physics.*

4b. *General Physics.*—This course is a continuation of 4a and includes the study of electricity and magnetism, sound, and light. The following subjects are presented in the study of electricity and magnetism: Static electrification, potential, quantity, capacity, resistance, induction, impedance, inductive capacity, and electric waves. During the latter part of the term the reflection, refraction, diffraction, and interference of sound and light are studied. The entire course is illustrated by lecture experiments and supplemented by work in the laboratory.

Junior year, first term, five hours per week.

Text: Watson's *General Physics.*

5. *Laboratory Work in Mechanics, Sound, Light, Heat, Electricity, and Magnetism.*—In the laboratory, the work is quantitative, and aims, as far as possible, to instruct the student in the methods of physical measurement and the derivation of relations between the quantities measured. Emphasis is laid upon the derivation of physical laws rather than the verification of them.

Sophomore year, third term, two afternoons per week; Junior year, first term, two afternoons per week.

6. *Thermodynamics.* — A short course in theoretical thermodynamics is followed by a study of boilers, furnaces, and heat engines, standard types of safety and tubular boilers, chimney and mechanical draft, pumps, and heaters. Steam, gas, and gasoline engines are also studied. Recitations and lectures are supplemented by the equivalent of one afternoon per week in the steam laboratory, where practice is had in operating and indicating engines; measuring chimney draft, boiler evaporation, and the calorific value of fuels.

Junior year, second term, five hours per week; laboratory work, second term, one afternoon per week.

Text: Reeve, *Thermodynamics.*

7. *Dynamo Machinery.*—This course discusses the magnetic circuit of dynamos and motors, with methods of connecting for operation in series and parallel; characteristic curves, and methods of testing dynamos and motors.

Senior year, first term, three hours per week.

Text: Sheldon, *Dynamo Machinery.*

8. *Alternating Current Machinery.*—In this course typical single and polyphase generators, synchronous and induction motors, stationary and rotary transformers, are studied. The effect of frequency, induction, and capacity upon the impedance of circuit are presented by the graphical and analytical solution of numerous problems in transmission and distribution.

Senior year, second term, five hours per week.

Text: Sheldon and Mason, *Alternating Current Machinery.*

9. *Electrical Transmission.*—This course includes the continuous current circuit, single and polyphase alternating-current transmission, series and parallel distribution, design of the conducting system, and overhead and underground construction. Lectures and recitations supplemented by one afternoon per week in electrical problems.

Senior year, third term, three hours per week.

10. *Dynamo Laboratory.* — During the first term the work is in connection with the course in dynamo machinery and during the second term it is in connection with the course in alternating-current machinery. The work includes the calibration of instruments, characteristic curves, efficiency tests of dynamos, motors, transformers, converters, line resistance, capacity inductance, impedance, and insulation measurements.

Senior year, first and second terms, two afternoons per week.

Graduate Courses.

11. *Theory of Electricity and Magnetism.* — In this course a mathematical treatment of electricity and magnetism is presented for graduates and advanced under-graduates.

First and second terms, three hours per week.

12. *Alternating Currents.* — This course supplements Course 8 and includes an analytical geometrical treatment of the subject.

First and second terms, two hours per week.

13. *Dynamo Design.*—This course is open to those students who have completed Courses 8 and 9 and includes the design of dynamos, motors, alternators, and transformers.

Third term, three afternoons per week.

CIVIL ENGINEERING.

Professor Harris, Mr. Howe, Mr. Baueris, Mr. Garst, Mr. Park.

Equipment.

Civil engineering occupies the greater portion of the third floor, including two large drafting rooms amply lighted and equipped for the work above the Freshman year, a blue-print room, two large lecture rooms, and a department library and study.

The equipment for field practice includes thirteen transits and one theodolite, one plane table, one solar compass, one railroad compass, eleven levels, together with barometers, meters, chains, tapes, level rods, tools, and other necessary equipment for field practice. A number of the transits are adapted for underground surveying.

The experiment room is located on the first floor and is equipped with separate lockers for the equipment of each surveying squad.

The testing laboratory is located in the basement and is equipped with suitable machinery for making tests on engineering materials.

Courses.

1. *Surveying.*—This consists of a course in general surveying, including the use of the transit, the level, and the solar compass. Students are required to plot to scale the areas surveyed and to complete the map in all its details. Following this work, city surveying and topographic methods are taught.

Sophomore year, first term, three hours per week.

1a. *Field Practice.*—Students in Civil Engineering have field practice three afternoons per week during the first and third terms of the Sophomore year; the other students in surveying have field practice two afternoons per week during the first term of the Sophomore year.

1b. *Topography.*—The students are divided into parties, each with a captain, and to each is assigned an area to be covered. One week is given to this work in the Sophomore year. From notes so taken, the Civil Engineering students are required to produce a finished topographic map in the first term of the Junior year.

1c. *Geodesy.*—In this course the student studies higher problems in surveying, including engineering astronomy, base-line measurements, and precise leveling.

Sophomore year, second term, three hours per week, Civil Engineering Course.

1d. *Geodesy — Computations and Drawings.* — In this course the student is given exercises in mapping and platting, in the determination of areas, and in the partition of land. He learns to solve systematically the problems in geodesy.

Sophomore year, second term, three afternoons per week, Civil Engineering Course.

2. *Lines of Communication.*—This course covers the mathematical problems in the location of railways, highways, and canals, and in setting out and estimating earthwork, laying out track, and locating tunnels.

Sophomore year, third term, lectures and recitations two hours per week, Civil Engineering Course; Junior year, third term, lectures and recitations two hours per week, Mining Engineering Course.

Field Practice, Sophomore year, third term, three afternoons per week, Civil Engineering Course; Junior year, third term, one afternoon per week, Mining Engineering Course.

3. *Railway Economics.*—This course treats of the economic principles of railway location and improvements of old lines as affected by curvature grades, first cost, cost of maintenance, and traffic.

Senior year, first term, two hours per week, Civil Engineering Course.

4. *Masonry Construction.* — The course treats of the economic properties of building stone, brick, and cements; the proportioning, mixing, and placing of mortars and concrete; preparation of foundations and strength and stability of masonry structures, including dams, piers, abutments, retaining walls, and arches.

Junior year, second term, two hours per week.

5. *Engineering Laboratory.*—This includes tests determining the strength and properties of building materials of various kinds, including stone, brick, cement, concrete, cast-iron, steel, and wood. Special attention is paid to tests of cement and cement mortar and concrete.

Junior year, second term, two afternoons per week, Civil Engineering Course.

6. *Roads and Pavements.*—This course discusses the principles involved in the location and construction of highways, streets, and roads, and the merits of the various methods of paving.

Junior year, second term, two hours per week, Civil Engineering Course.

7. *Masonry Designs and Concrete Steel.*—This course treats of the higher structures in masonry, including arches, dams, and portals, and the art and theory of concrete-steel structures. The properties, uses, and economy of cement are discussed. The student is required to prepare drawings and specifications of as many structures as possible during the time available.

Senior year, third term, five hours per week, Civil Engineering Course.

8. *Hydraulics.*—This course covers the theory of hydrostatics and of hydraulics; the determination of experimental co-efficients and their use as applied to the flow of water through orifices, weirs, pipes, and canals. Also the theory of hydraulic motors and dynamic pumps.

Junior year, third term, five hours per week.

9. *Water Supply.*—This course covers the selection, impounding, transporting, and delivering of water supply to cities and towns.

Senior year, first term, five hours per week, Civil Engineering Course.

10. *Sanitary Engineering.*—This course treats of the necessary precautions for the protection of water supplies from pollution and the methods available for the purification of contaminated supplies. It also includes a study of the principles involved in the collection and disposal of sewage and storm waters, and sewer construction.

Senior year, second term, lectures and recitations five hours per week, Civil Engineering Course.

11. *Irrigation.*—This is a short course designed to emphasize essential details of the location of canals, headworks, impounding reservoirs, and supplementary work.

Senior year, third term, lectures and recitations three hours per week, Civil Engineering Course.

12. *River and Harbor Improvements.*—This course reviews the control of flood water, the protection of river banks, the improvement of navigation, and the protection and improvement of harbors.

Senior year, third term, lectures and recitations two hours per week, Civil Engineering Course.

13. *Frame Structures.*—This course, designed alike for students in Mining and Civil Engineering, treats of general methods of determining stresses in such structures as single-span bridges, roof-trusses, towers, derricks, and of the design of individual members, as posts, beams, and rods to carry specified stresses.

Senior year, first term, two hours per week, Mining Engineering Course; Senior year, first term, five hours per week, Civil Engineering Course.

14. *Bridges (Higher Structures).*—This course is for students in Civil Engineering only and introduces the study of arches and cantilever, swing, and suspension bridges.

Senior year, second term, five hours per week.

15. *Drawing and Graphics.* — Students in Civil Engineering are required to complete a topographic map during the Junior year. This is followed by an exercise in the elementary problems of graphic statics as applied to single-span bridges and roofs and to masonry structures.

Junior year, second term, four afternoons per week; Junior year, third term, two afternoons per week; Senior year, first term, three afternoons per week, Civil Engineering Course.

16. *Engineering Designs.*—This is a practical course in the design of steel bridges, concrete steel structures, water supplies, and sewage systems.

Senior year, first and second terms, three afternoons per week, Civil Engineering Course.

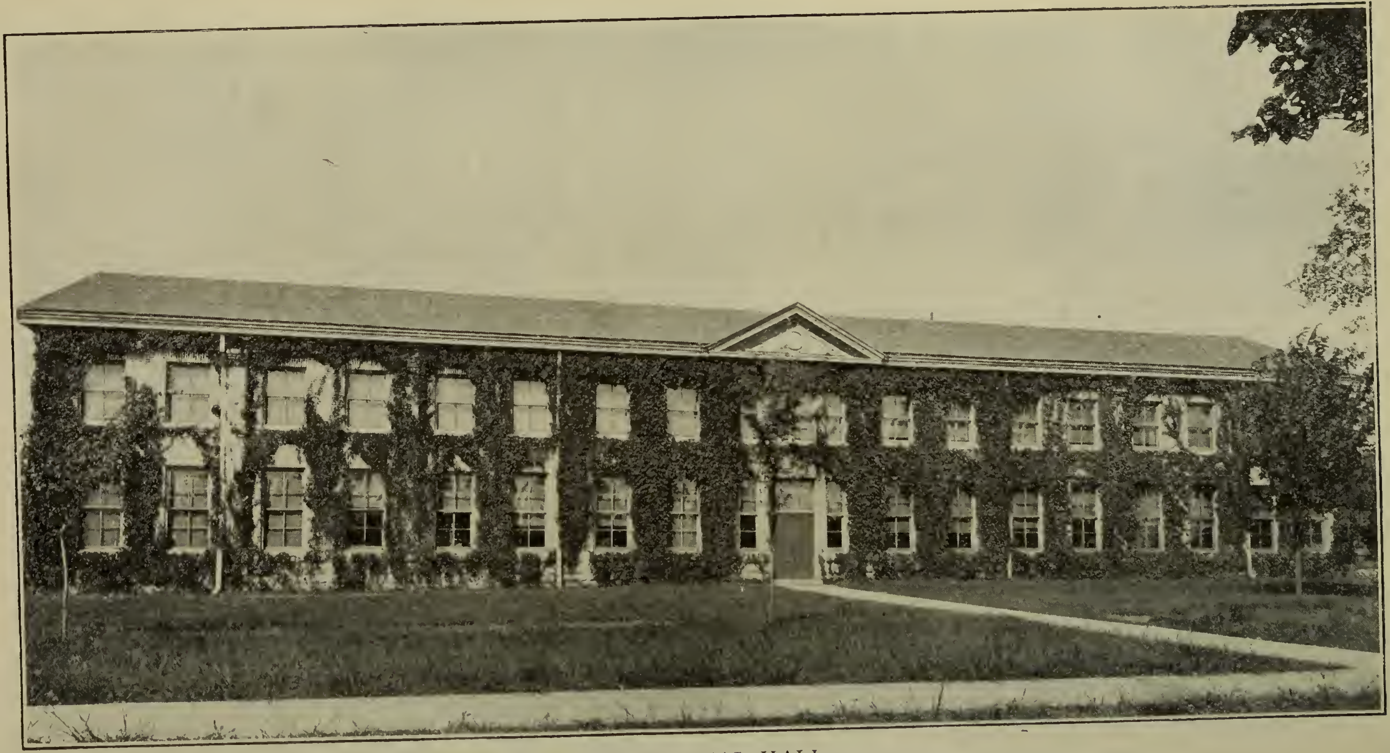
17. *Special Investigations (Thesis).*—In the third term of the Senior year, all graduating students give two afternoons per week to original investigation in some subject which they select, with the approval of the Faculty.

18. *Compressed Air.*—This course covers the laws governing the compression and piping of air and the application of compressed air to the industries.

Senior year, second term, lectures and recitations two hours per week; laboratory, Senior year, second term, one afternoon per week.

19. *Astronomy.*—A course in general astronomy is given for students in Civil Engineering.

Junior year, third term, two hours per week.



MECHANICAL HALL.

MINING ENGINEERING.

DIRECTOR YOUNG.

The School of Mines and Metallurgy offers a regular four-year course in Mining Engineering. At the beginning of the Senior year three options are offered in place of the Senior course of study in the regular Mining Engineering Course.

Equipment.

The surveying equipment already referred to in Civil Engineering is used for mine surveying. The School of Mines has several thousand drawings and blue-prints of mining machinery and mine plants which are used in connection with work in mining and mine management. There are also in the Library a large number of lantern slides and photographs illustrating mining practice in the United States.

The laboratories contain air-compressors, pumps, rock-drills, special drill steel, and models of mine timbering, which are used for demonstration and experimental work.

Courses.

1. *Mining Machinery.* — This option is designed for those students who desire to specialize along the mechanical side of Mining Engineering. Less time is given to metallurgy and geology and more time to machine problems and laboratory.

2. *Ore Dressing.* — This option is designed for those students who desire to specialize in concentration of ores. More time is given to ore dressing, both theoretical and applied, with a correspondingly longer time for laboratory work. Less attention is paid to geology than in the regular course.

3. *Mining Geology.*—This option is designed for those students who desire to specialize along the geological side of mining and gives less time to metallurgy and ore dressing and more time to geology.

The options lead to the common degree of Bachelor of Science in Mining Engineering. The course of study includes the following subjects:

1. *Elementary Mining.*—This short course outlines the principles on which the science of Mining Engineering is founded, and is designed to introduce the student to fundamentals which will enable him to appreciate the applications of the other studies of the Freshman and Sophomore years.

Freshman year, first term, two hours per week.

2. *Mine Surveying.*—The theory and the practice of the surveying of mineral lands and mines are presented by lectures. Many problems are introduced and the student is trained in various calculations, including the reduction of notes of underground surveys requiring the auxiliary telescope, volumes of stopes, mineral acreage, intersections of veins, underground connections, and general problems in the determination of the location of mine openings. A mine surveying trip to the Joplin district is a required part of the work of the Junior year.

Sophomore year, first term, two hours per week, Mining Engineering Course.

3. *Mining.*—This course includes lectures on prospectting, drilling, blasting, boring, tunneling, shaft-sinking, and mining methods. The various tools and appliances used in these operations are described. A review of methods of mine timbering is included in the course.

Sophomore year, second term, two hours per week, Mining Engineering Course.

The same course is given in the summer school.

4. *Mining.*—This course is a continuation of Course 3 and includes lectures in mine haulage, hoisting, mine drainage, mine ventilation, lighting, accidents, and hygiene.

Sophomore year, third term, three hours per week, Mining Engineering Course.

5. *Junior Trip.*—At the end of the school year the members of the Junior class make a three weeks trip to the mining districts of southeast and southwest Missouri. The purpose of the trip is to give an opportunity for the study of the methods of mining and the concentration of ores in the districts visited, together with work in mine surveying and geology.

A complete report of the work of the trip is required.

6. *Mining Law and Contracts.*—The general principles of mining law are reviewed with discussions of legal decisions in representative cases. The students are given the general principles governing the making of contracts, together with discussions of contracts typical of various mining districts.

Senior year, first term, two hours per week, Mining Engineering, Civil Engineering, and Metallurgy Courses.

7. *Mine Management.*—This course is planned to give the student an idea of the principles of management of mining enterprises, and reviews methods of mine organization, mine accounting, and presents economic problems in connection with mine management. The practice of mine examination and mine reporting is reviewed.

Senior year, third term, two hours per week, Mining Engineering Course.

Texts: Rickard, *Economics of Mining.*
Rickard, *Ore Sampling.*

8. *Mining Machinery Laboratory.*—Prior to undertaking laboratory work on special mining machinery, the student is given a thorough training in the machine shop. This work includes chipping to a line, filing to a dimension, and scraping to a surface plate; the principles and uses of the drill-press, planer, lathe, shaper, and milling machine. In this work use is made of the vernier micrometer, thread micrometer, and gear-tooth caliper. The degree of accuracy

thus acquired enables the student to use eye and hand in unison and is of lasting benefit in teaching exactness in statement and measurement.

Special attention is given to various types of mining machinery and to the study of steel and other materials which enter into the construction of such machinery.

Laboratory work, Senior year, first term, one afternoon per week; second term, three afternoons per week, Mining Machinery Option.

9. *Mining Machinery.*—This course includes an outline of the various types of machinery used in mining operations and is planned to familiarize the student with the best designs of machinery in order that he may be able to select the proper machine for the particular condition, that he may know when each machine operates efficiently, and know how to keep the machine in a first-class condition.

The machinery studied includes rock-drills, coal-cutters, mine-hoists, mine-pumps, mine-locomotives, wire-rope haulage systems, mine-fans, excavating machinery, and safety appliances.

Senior year, second term, four hours per week; third term, five hours per week, Mining Machinery Option.

10. *Mining Machinery Problems.*—This course is a continuation of Course 8, and includes advanced work in the machine shop in connection with mining machinery. The methods of testing various machines under working conditions are presented and whenever possible such tests are carefully carried out underground.

Senior year, third term, two afternoons per week, Mining Machinery Option.

GEOLOGY AND MINERALOGY.

ASSISTANT PROFESSOR GRISWOLD, MR. COREY, MR. DON.

Equipment.

The mineralogy laboratories are on the second floor of Norwood Hall. They are equipped with suitable tables for the examination of minerals and rocks. They contain the extensive collections of wooden and glass models and the reference and working mineral collections. The laboratory for lithology contains a representative collection of rocks for reference and a large working collection.

The geological and mineralogical equipment includes a representative collection of minerals, rocks, and fossils for class use; a large collection of cabinet specimens of minerals and ores, and of materials illustrating metallurgical processes. There have been recently added to the equipment of this department several large geological relief models, which aid materially in the work in stratigraphical structural geology.

There is also a collection of thirty-five hundred specimens, representing the mineral wealth of Missouri, consisting of coal, clays of many sorts, and building stones, and ores of lead, zinc, iron and copper. The minerals occurring as gangue with the metalliferous deposits of the State are also well represented. There is also a complete collection of the economic minerals of Missouri and a good economic geological collection representing the world at large. This collection was a part of the Missouri Mineral Exhibit displayed at the World's Fair at Chicago. It was presented to the School of Mines and Metallurgy by the General Assembly in 1895.

In addition to the above mentioned collection, the State Board of Equalization assigned to the School the specimens, models, maps, and machinery which constituted the Missouri Mining Exhibit at the St. Louis Exposition, thus giving to the School a large amount of valuable equipment.

The Museums contain crystals and minerals from various important mining districts of the State of Missouri, the economic collections from southwest Missouri, the great geological relief map from the St. Louis Exposition, polished stone tables and other complete collections of the Missouri Building and ornamental stones from the same exposition.

A rock section machine and instruments for geological surveys are included in the equipment of this department.

Courses.

1. *Mineralogy.*—This course consists of lectures and laboratory work. Crystallography is studied first and is followed by the investigation of the physical characters of the minerals. Special attention is given to the ores, gangue minerals, non-metallics of economic value, and the rock-forming silicates.

Lectures, Freshman year, third term, two hours per week; Sophomore year, first term, two hours per week.

Laboratory work, Freshman year, third term, two afternoons per week; Sophomore year, second and third terms, two afternoons per week.

The work of the first two terms is repeated during the summer school.

Text: Dana, *Mineralogy.*

2. *Lithology.*—The course is elementary in character; the igneous rocks are studied with reference to texture and mineral composition, and the sedimentary rocks chiefly with reference to structure.

Lectures, Sophomore year, second term, two hours per week.

Laboratory work, Sophomore year, second term, one afternoon per week.

Text: Kemp, *Handbook of Rocks.*

3. *Petrography.* — The subject is divided into optical mineralogy and lithology. The igneous rocks are first studied, then the sedimentary and the metamorphic rocks. The course

is designed to meet the needs of the mining engineer and the mining geologist. A large amount of time is given to the study and determination of hand specimens.

Senior year, first and second terms, three hours per week; third term, two hours per week, Mining Geology Option Course.

Texts: Kemp, *Handbook of Rocks;*
Iddings, *Rock Minerals.*

4. *General Geology.*—This is a lecture course involving the principles of general and economic geology. It discusses the evolution of the earth, its present condition, and the processes which have modified its crust and surface.

Junior year, first term, five hours per week; second term, three hours per week; third term, five hours per week.

Text: Scott, *An Introduction to General Geology.*

5. *General Geology Laboratory—Structural Geology.*—The student has work upon geological models, maps, and photographs, with the view to interpreting geological structures and land surface forms.

Junior year, second term, one afternoon per week.

Field Work.—The student visits various localities near Rolla with the instructor and has the various types of geology explained; then he is assigned an area to map geologically.

Junior year, third term, two afternoons per week.

The course is supplemented by the summer field excursions to southeast Missouri.

6. *Economic Geology.*—This is a series of lectures dealing with the occurrence, origin, and distribution of ores, clays, building stones, gems, water supply, and other products of economic value from the different geological formations. The characteristics and genesis of ore deposits are carefully considered. The members of this class visit local points of economic importance near Rolla, studying iron, lead, coal, clay, and building-stone, besides making an excursion to the zinc-lead district of Joplin.

Senior year, first and second terms, three hours per week; third term, five hours per week.

Text: Ries, *Economic Geology of the United States.*

7. *Geology of the United States.*—This lecture course considers the various geologic and physiographic provinces of the United States and adjacent areas in the relation to geological development and economic interest.

Optional for Seniors, first term, three hours per week.

8. *Geological Conference.*—The conference consists of a discussion by the students and instructors of geological literature or problems associated with extra reading or with the laboratory work of the term.

Optional for Seniors, second term, two hours per week.

9. *Structural and Metamorphic Geology.*—In this course various type regions of the world are studied in detail with reference to structure, to metamorphism, and to their combinations.

Optional for Seniors, third term, three hours per week.

10. *Senior Geological Laboratory.*—(a). One afternoon per week is given to mapping a local area, the resulting map to be accompanied by a geological report.

Senior year, first term, Mining Engineering Course.

(b). This includes the drawing of maps and sections and some experimental work, planned with reference to the Geological Conference (Course 8) and to Structural and Metamorphic Geology (Course 9).

Senior year, second term, two afternoons per week.

(c). Excursions are made to various localities and economic interest within easy reach of Rolla and also to the Joplin district.

Senior year, third term, one afternoon per week, Mining Engineering Course; optional for Seniors, third term, one afternoon per week.

11. *Paleontology.*—The course is designed to serve as an introduction to historical geology.

Senior year, first and second terms, four hours per week.

Laboratory work, Senior year, second term, two afternoons per week.

Text: Zittel, *Paleontology.*

12. *Historical Geology.*—The stratigraphical development of the United States is taken up in as much detail as time permits.

Senior year, third term, four hours per week.

METALLURGY AND ORE DRESSING.

PROFESSOR COPELAND, MR. DUDLEY, MR. MANN,
MR. ANDERSON.

Equipment.

The assay laboratory has a floor space of forty-eight hundred square feet. The main room contains twenty coal-fired double-muffle assay furnaces, twelve gasoline-fired furnaces, and ten coke-fired furnaces. Desks containing lockers, pulp balances, and fluxes are arranged close to the furnaces.

The parting room contains the necessary hot plates, stills, and muffles. The balance room is equipped with eleven fine balances.

The main metallurgy laboratory is well equipped with hoods and sinks and contains fifty-six desks and lockers. This laboratory is used especially for metallurgical testing of various kinds.

The west wing of the Ore Dressing Building is equipped with a 20-inch water-jacket blast-furnace with a Root blower, for reduction of lead and copper ores. There is also in this laboratory an experimental hand reverberatory roaster, an experimental pot roaster, an experimental zinc distilling furnace, a Deville clay-testing furnace, Le Chatlier thermoelectric pyrometers, a Wänner optical pyrometer, a cyanide testing outfit with 100-lb. capacity tanks, a laboratory tube-mill, and laboratory amalgamating pans.

A special ore dressing laboratory is provided for investigation and thesis work. The mill-room is equipped with first-class machinery for the crushing and concentration of ores. The plant contains a Knowles magnetic separator, a Dodge rock-breaker, a Webb City crusher, Cornish rolls, three sets of sample rolls, a stamp-battery with automatic feeder, hydraulic classifiers, Spitzkasten, three New Century jigs, one Standard table, one Card table, one Sperry slimer, Parsons-Rittinger percussion tables, a Frue vanner, grinding and amalgamating pans, and settlers, elevators, and trommels. In addition to this, working models of different types

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ORE DRESSING BUILDING

of concentrators have been made by students of the School of Mines and contributed to this outfit. Several thousand blue-prints illustrating the design of concentrating plants and ore dressing machinery are easily accessible in the school library.

Courses.

The work in this department is designed to give students a thorough training in all branches of metallurgy.

It is recognized that a school cannot give students, in the brief time at its disposal, that skill which comes from long practice, but it is the aim to give such training in the fundamental principles and their application, that students may become useful immediately on their entrance into the actual practice of their chosen profession. All metallurgical courses are accompanied by graded metallurgical problems, which give the student a technical command of the subject.

An important feature of the instruction is experimental investigation in the metallurgical treatment of various ores.

For convenience in recording and reporting, the subjects following are classified under the general letter M, with necessary subdivisions:

M-1. *Fire Assaying.*—This work includes the assay, by scorification and crucible methods, of ores from the various mining districts of the United States. Copper ores, copper mattes, and copper bullions are assayed by fire and by the combination method. Lead ores and furnace products are assayed for lead and for gold and silver. Assays of cyanide solutions, of zinc-box residues, of silver bullion, of gold bullion, of lead bullion, and of silver-mill precipitate, are included in this course. During the course the student has practice with coal furnaces, coke furnaces, and gasoline furnaces. Besides doing the ordinary work of assaying, the student studies the losses occurring. He learns the effects of different schemes of firing the furnaces by making analyses of the flue gases and by pyrometric measurements. The laboratory is so arranged that even with large classes a student is not hampered by other students and he learns to handle a large amount of work with the best utilization of his time.

The laboratory course is supplemented by lectures. The nature of the processes is thoroughly explained and the practical difficulties are discussed.

The same course is given in the summer school.

Text: Lodge, *Notes on Assaying.*

M-2. *General Metallurgy and Metallurgy of Iron.*—This course begins with general principles, including properties of metals and alloys, fuels, fluxes, calculation of charges, general study and classification of furnaces, followed by a study of processes employed for the production of cast iron, wrought iron, and steel.

Junior year, second and third terms, three hours per week.

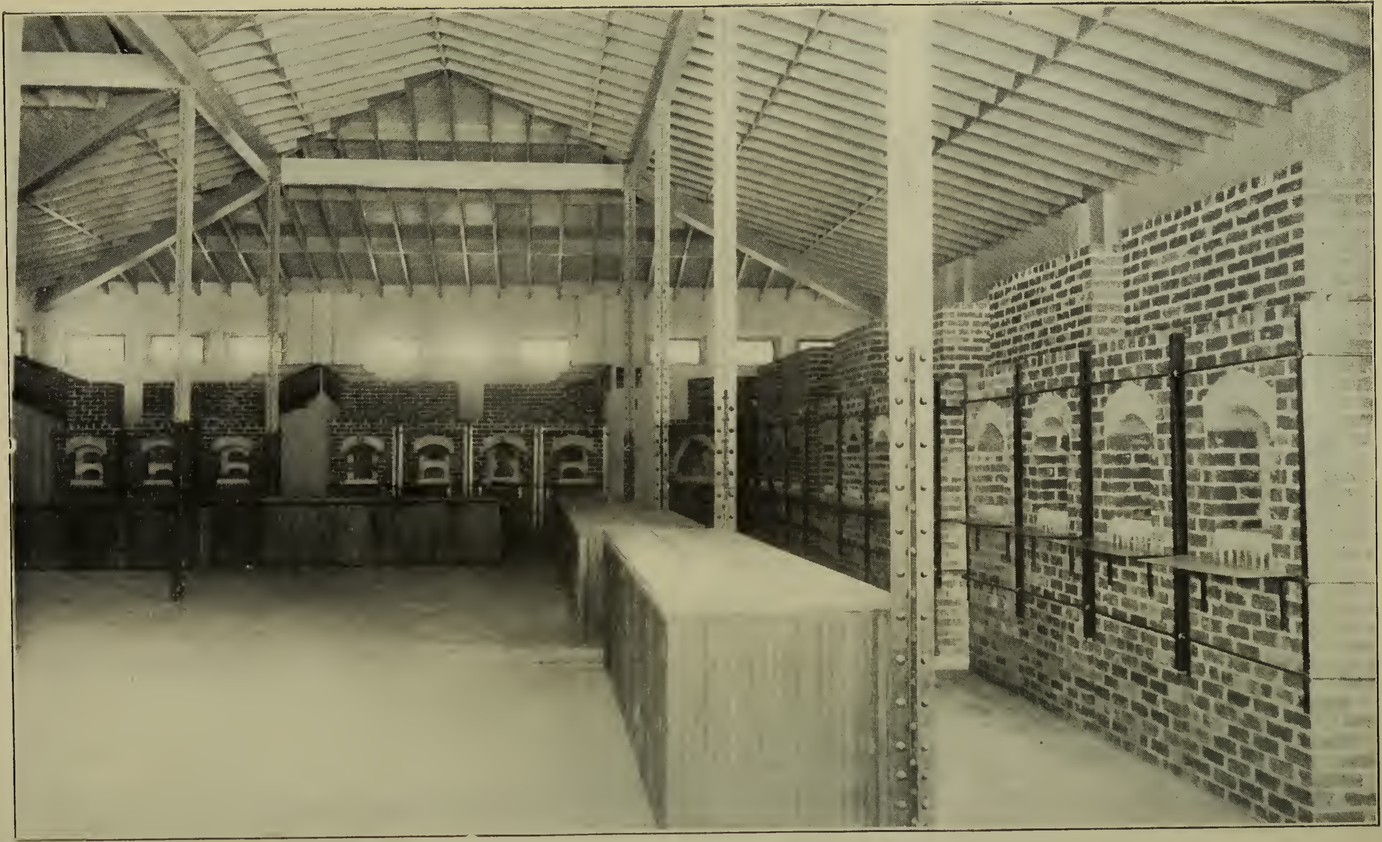
Text: Campbell, *Manufacture and Properties of Iron and Steel.*

References: Roberts-Austin, *Introduction;*
Howe, *Metallurgy of Steel.*

M-3. *Metallurgy of Lead and Silver.*—The properties and uses of lead, and of its alloys and compounds, are discussed in this course. A study is made of the principles and practice of sampling and purchasing ores. The major part of the course is given to the consideration of the standard and proposed methods for winning, desilverizing, and refining lead. Great stress is laid on the principles involved, and the student is referred to the text and to current literature for the details of processes. The winning of silver by smelting, amalgamation, and leaching is studied. Especial attention is given to cyaniding of silver ores. Throughout the course there is brought forward the commercial viewpoint as well as the view strictly technical.

Senior year, first term, four hours per week.

Texts: Hofman, *Metallurgy of Lead;*
Collins, *Metallurgy of Silver.*



COAL-FIRED ASSAY FURNACES

M-4. *Metallurgy of Copper, Nickel, Mercury, Tin, Antimony.*—The metallurgy of copper is the principal part of the course. The lectures deal with the properties and uses of copper and copper products, and with the principles employed in the winning and refining of copper. Inasmuch as the metallurgy of copper is continually changing it is necessary for the student to examine carefully the various technical journals and to note the improvements and also the varying conditions affecting the metallurgy of copper.

The metallurgy of nickel, mercury, tin, and antimony are discussed only briefly.

Senior year, second term, four hours per week.

Text: Peters, *Principles of Copper Smelting.*

M-5. *Metallurgy of Gold and Zinc.*—The course in the metallurgy of gold considers the extraction of gold by the standard methods. Especial attention is given to cyaniding. The rapid advances in cyanide practice are discussed in the class room, and laboratory experiments on debated points are encouraged.

The course in the metallurgy of zinc includes lectures on the properties of zinc and its compounds, the concentration of zinc ores, and the manufacture of spelter and of zinc paints.

Senior year, third term, two hours per week.

Texts: Rose, *Metallurgy of Gold;*
Ingalls, *Metallurgy of Zinc.*

M-6. *Constitution of Alloys.*—These lectures deal with the theoretical and practical considerations that influence the structure and properties of alloys of different types.

Senior year, first term, two hours per week, Metallurgy Course.

M-7. *Electro-Metallurgy.*—Lectures are given covering the electro-metallurgical processes that are in use. Efficiency and engineering calculations based on this and the required courses above mentioned.

Senior year, first term, two hours per week, Metallurgy Course.

M-8. *Metallurgical Organization.* — The course briefly takes up the principles of organization and the duties of officers and accounting force of a metallurgy plant. The outline shows the extent of the course. Organization of companies and working forces, management, superintendence, skilled and unskilled labor. Then following this, the constitution of capital, stocks, bonds, dividends, and profits.

Senior year, second term, three hours per week, Metallurgy Course.

Text: Conyngton, *Corporate Management.*

M-9. *Metallurgical Problems.*—These problems aim to cover the common ones that the metallurgist meets in practice. They are carefully chosen so as to represent as typical cases as possible.

Senior year, first and third terms, one hour per week, Metallurgy Course.

Text: Richards, *Metallurgical Problems.*

M-10. *Memoirs.*—The student in the Metallurgy Course is required to do a considerable amount of technical reading in German and English. Carefully prepared abstracts of valuable current articles are presented and read by the students themselves. These articles are chosen by reason of having special value along chemical or metallurgical lines.

Reports, Senior year, first term, one hour per week, Metallurgy Course.

M-11. *Metallurgical Laboratory.*—This course aims to familiarize the student with the use of calorimeters and pyrometers, and their calibration. Some insight is given into the ordinary methods of metallurgical investigation, and the methods of measurement which a metallurgist should know how to conduct.

Junior year, third term, one afternoon per week, Metallurgy Course.

Text: Howe, *Laboratory Notes.*

M-12. *Metallurgy Conference.*—This work is of great value to the student and aids him materially in getting the full value of his laboratory work.

Senior year, second term, one hour per week.

M-13. *Metallurgical Laboratory.* — This course covers the testing of ores for process of treatment. Ores are tested by cyaniding, chlorination, amalgamation, lixivation, concentration, and by combination methods. With aid of smelter schedules, the smelting costs are calculated and the net dollars and cents returns are balanced against the best results by any method, or combination of methods, worked out in the laboratory. The endeavor is made, not only to teach metallurgical principles in the laboratory, but also to bring home to the student the great effect which freight rates and other factors might have on the treatment which an ore should receive. Experiments are made in the reverberatory and "pot" roasting of ores, and on blast-furnace smelting of ores.

Furnace heat-equations are made by each student from data collected by himself.

The same course is given in the summer school.

Senior year, second term, one afternoon per week.

Text: Howe, *Laboratory Notes.*

M-14. *Metallography.*—This is a study of the microstructure of iron and steel and of the effects of heat treatment.

Senior year, second term, one afternoon per week, Mining Engineering and Metallurgy Courses.

M-15. *Metallurgical Problems.*—This course has reference to the designing and proportioning of various types of furnaces for special duties and conditions. It necessitates a clear conception of metallurgical principles.

The alternative, electro-metallurgical problems, will cover the design and estimates for a copper or copper-nickel refinery.

M-16. *Electro-Metallurgy Laboratory.* — This course gives a study of the principles of electro-metallurgy from the standpoint of experiments actually performed. Tests are made on the electrolytic refining of copper and of lead bullion. Experiments are performed and calculations as to efficiency are made on electric smelting.

Senior year, first term, two afternoons per week, Metallurgy Course.

M-17. *Metallurgy Plant.*—The arrangements of various metallurgical works are studied. The advantages and disadvantages of different equipments are given. Throughout the entire course stress is laid on the financial problems.

Graduate course, second term, three hours a week.

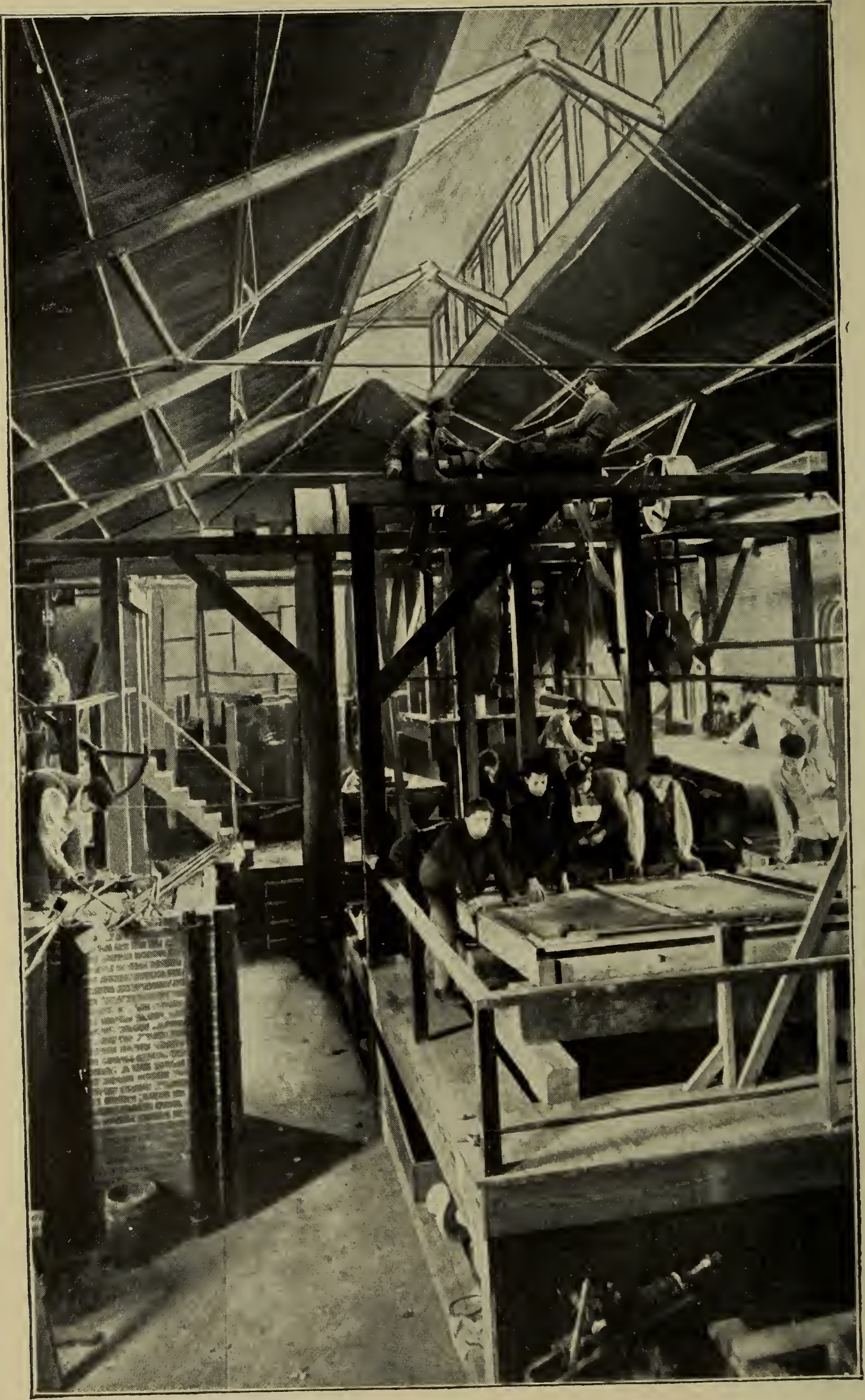
M-18. *Metallurgy Plant Design.*—This is a drafting-room course, and the student is given problems to solve in detail, covering a part of the class room discussions. Each student is required to submit complete drawings, specifications, and estimations of cost.

Graduate course, second term, three hours a week; third term, nine hours a week.

M-19. *Cyaniding.*—This course teaches the principles and practice of cyaniding. The student keeps up with the progress in the art. Attention is given in all the work to the costs of operation and to the schemes used and proposed for lessening the cost. A detailed study is made of the types of filter presses, crushing machinery, and other devices used in cyanide mills. Cyaniding is compared with other possible methods of reduction.

Graduate course, first and second terms, three hours a week.

M-20. *Cyanide Laboratory.*—The student in this course has an opportunity to test in the laboratory the methods discussed in the class room. The work is not routine, but the experiments are arranged to bring out a point under discussion or to solve, if possible, the problems occurring at the time in the class room.



ORE DRESSING LABORATORY

Graduate course, first and second terms, six hours a week.

M-21. *Ore Supply.*—This course is intended to bring out the important subject of ore, flux, and fuel supplies. The subject is studied from a combined commercial and technical standpoint. The problems of valuing fluxes and fuels, of mixing ores so that the mixture shall command the lowest treatment rate, and of preparing, from the reduction works standpoint, treatment charges for different classes of ores, are studied.

Graduate course, third term, three hours a week.

M-22. *Metallurgical Research.*—Each graduate student elects a subject for special study. It is recommended that the work be along a different line from the subject chosen for thesis. The course consists principally of assigned reading, together with conferences with the professor on the matter read. The laboratories are always open for the solving of any problem that may arise.

Graduate course, five hours a week throughout the year.

O. D. 1. *Elements of Ore Dressing.*—In this course the principles of all common ore dressing processes are briefly discussed. The various machines used for crushing, classification, and concentration of ores are described. Especial attention is given to those processes and mill schemes which the student has opportunity to see while on the Junior trip.

Junior year, third term, three hours per week.

Text: Richards, *Ore Dressing.*

O. D. 2. *Ore Dressing.*—In this course the principles of mechanical ore treatment are discussed in detail. The construction and theory of machines are presented in lectures, supplemented by a full equipment of models, which show the design of all common ore dressing appliances.

The latter part of the course deals with the management of mills, and with the adaptation of processes to the successful treatment of various ores.

Senior year, four hours per week, throughout the year.

Text: Richards, *Ore Dressing.*

O. D. 3. *Ore Dressing Memoirs.*—The student is required to do considerable reading and to prepare abstracts of articles appearing in the current technical literature. Articles of special interest in ore dressing are assigned for discussion at the weekly conference.

Conference, Senior year, third term, one hour per week.

O. D. 4. *Ore Dressing Laboratory.*—The student becomes familiar with the operation and care of milling machinery by actual laboratory experience. All types and classes of machines are available to illustrate principles and practice as presented in the lecture work. The laboratory is so arranged that a number of mill schemes may be utilized and processes for treating a particular ore can be determined from mill tests on large quantities of the ore.

Senior year, first term, two afternoons per week.

O. D. 5. *Ore Dressing Laboratory.*—This course is more extensive than Course 5. Besides the regular mill practice, the student makes sizing tests upon the products of breakers, and determines the quality of work done by concentrating machines under varying conditions. Each student is assigned independent experimental work involving the theoretical principles, which are of importance in ore dressing.

Senior year, first term, three afternoons per week; third term, two afternoons per week, Metallurgy Course and Ore Dressing Option Course.

O. D. 6. *Ore Dressing Problems.*—In this course advanced work is given in connection with the design of plants and machinery for the treatment of ores. The course includes the determination of a practical process for treating a given ore, and the design of a mill for utilizing this process.

Drafting room work, Senior year, second and third terms, one afternoon per week.

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WOOD SHOP

SHOP PRACTICE AND DRAWING.

ASSISTANT PROFESSOR BOWEN, MR. SMITH.

Equipment.

The shops are thoroughly equipped with machinery and benches adapted to instruction. The wood bench work-room contains twenty double benches with separate sets of hand tools. The lathe-room is equipped with twenty Fay & Egan 12-in. swing college wood lathes and iron shears. The other machines in the lathe-room include a Fay & Egan 27-in. planer, a Fay & Egan bandsaw with 30-in. wheels, an Oliver universal saw-table, two Oliver wood trimmers, a mortise machine and jig-saw, grinding saws, and other necessary tools.

For instruction in forge work there are twenty-four Buffalo Forge Company down-draft forges, power hammer, drill-press, power shears, and grinder.

The metal-working room contains

One 20-in. by 8-ft. Reed Lathe.
One 12-in. by 6-ft. Reed Lathe.
One 12-in. by 5-ft. Reed Lathe.
One 14-in. by 6-ft. Hendey Lathe.
One 14-in. by 6-ft. American Lathe.
One No. 2A Brown & Sharpe Universal Milling Machine.
One Hendey 15-in. Pillar Shaper.
One Dwight Sensitive Drill.
One Barnes 22-in. Swing Upright Drill Press.
One 24-in. Morse Double Emery Grinder.
One 24-in. by 24-in. by 6-in. Chandler Planer.
Two Grunard Arbor Presses, No. 3½ and No. 1.
One No. 1 Burr Cold Saw.
One 3-fire Chicago Flexible Shaft Gas Furnace.

All of the above mentioned iron-working machinery is of latest design and driven by individual motors. The benches in the lathe-room have hardwood tops mounted on standard

Brown & Sharpe bench legs. Twenty-four machinist vises, twelve of which have the swivel base and jaw, equip the shop for bench work.

The drawing rooms are equipped with double drawing tables and will accommodate two hundred forty students working in two sections.

Courses.

1. *Wood Work.*—The work in this course begins with simple exercises in planing and marking with the gauge and knife. It continues until the pupil has become thoroughly familiar with the use of the plane, bevel, square, gauge, and knife. He is then given graded exercises covering rip and cross-cut sawing and sawing to a "fit." Following this comes work at joints designed to show the different methods of construction, glue joints, doweling, dove-tails, and braces. This work is supplemented by talks on the tools and work in hand, and each student is required to pass a written examination on notes covering the classification and use of hand tools and accessories.

This preliminary work is followed by the construction of a drawing desk of our own design, which is a very rigid and substantial individual desk. It is designed for two sections, each student having a separate drawer and locker for instruments and drawing board, where they are free from disturbance and dust. Following the desk comes wood turning, which is designed to familiarize the student with the use of the lathe. He is given graded exercises, beginning with a plane cylinder, including curves of various kinds and sizes, and concluding with face plate work in rings, balls, goblets, and vases. On all the preliminary work students are required to use the tools in such a way as to make the use of sandpaper unnecessary.

A final part of this course is cabinet-making, designed to give the student work on the planer, universal saw-table, wood-trimmer, scroll-saw, and mortise-machine. After becoming familiar with the different machines, pattern-making is

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FORGE SHOP

begun, the purpose of this work being to teach the student to make representative types of patterns from which castings may be made. The principles of the shrink rule are explained, and drawings, such as are used in manufacturing plants, are made in order to teach the use of the finish marks, core boxes, and all conventional signs.

All work is done from drawings.

Freshman year, second term, two afternoons per week.

2. *Forge Work.**—This course begins with simple exercises in drawing, upsetting, bending, twisting, punching, and welding. The work gradually becomes more difficult, such as making eye-bolts, chains, and tongs. Tool-making is then begun by making screw-drivers, hammers, chisels, and a complete set of lathe tools, which will be used later in the machine shop. This work is fully illustrated by drawings and lectures on the subject, covering the properties of the different grades of iron and steel. The instructors make the student familiar with the best grade of steel to be used for any required purpose, and the correct shape and temper necessary for the best work in cutting iron, steel, brass, and stone. The final and most important part of this work is the testing of rock-drills of different makes, care being taken to preserve the results of the tests on different grades of steel used.

Sophomore year, two afternoons per week during the entire year.

3. *Metal Work.*—This course begins with chipping to a line, filing to a dimension, and scraping to a surface plate. Machine operation is then begun; the principles and uses of the drill-press, lathe, planer, shaper, and milling machine are taught by lectures followed by practical work at each machine. After a reasonable time, skill is attained in operating the various machines through a course of graded exercises. Students are required to build complete machines de-

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*Students may elect three terms in machine drawing instead of three terms in forge work.

signed by upper classmen or by the instructor. In this work use is made of the vernier micrometer, thread-micrometer, and gear-tooth caliper. The degree of accuracy thus acquired enables the student to use eye and hand in unison, and is a lasting benefit in teaching exactness in statement and measurement.

This is a part of the course in Mining Machinery Laboratory, described as Course 12 in Mining Engineering.

4. *Mechanical Drawing.*—The student is first given practice in geometrical construction until he is familiar with the nature, care, and use of drafting instruments. Then, after carefully studying the principles of orthographic projection, intersection, and development, he is thoroughly drilled in free-hand lettering. The course is completed with one term of machine drawing. In this the student is required to make sketches, detail and assembly drawings of machines, and is taught the principles of elementary machine design.

Freshman year, six hours per week throughout the year.

Texts: Anthony, *Mechanical Drawing;*
Wilson, *Free-Hand Lettering; Machine Drawing.*

5. *Machine Drawing.**—This course is a continuation of the work in mechanical drawing of the Freshman year. It includes exercises covering gearing, power transmission, mechanism, and the simpler machines used in mining, ore dressing, and metallurgy.

Sophomore year, two afternoons per week throughout the year.

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*Students may elect three terms' work in the forge room instead of three terms' work in machine drawing.

ENGLISH.

MR. SCOTT.

Efficiency in oral and in written expression on the part of the engineer is no longer considered among teachers in technical schools a matter of secondary importance. Efficiency in English, like that in any purely technical subject, can be acquired only by a systematic study of the principles underlying the subject, followed by long apprenticeship of practice under judicious criticism.

No credit for advanced standing in English will be given unless the work for which the credit is asked was done in the collegiate department of an accredited college or in the Junior or Senior year of a State normal school.

1. *Theme Work.*—All Freshmen are required to write, throughout the year, short, daily, and long, fortnightly themes. This work is carefully criticised by the teacher, corrected by the student, and returned to the critic as evidence that the student has profited by the criticisms.

2. *Rhetoric.*—Phases of this subject, too complex for the high school, are studied.

Freshman year, five hours a week throughout the year.

Texts: Brewster, *Representative Essays on the Theory of Style;*
Pearson, *Principles of Composition;*
Baldwin, *College Manual of Rhetoric.*

3. *Advanced English.*—All Sophomores are required to write at least one long theme each month. The forms of composition represented by these themes will be exposition and argumentation. An equal number of subjects are selected from each form and are criticised in the same manner as the Freshman themes.

The work in Advanced English is divided between the critical study of technical literature and the masterpieces of English and American literature, including the literature of some of our best magazines.

Sophomore year, one hour a week throughout the year.

4. *General Science English.*—The major part of the course will consist of the theoretical study of the forms of composition known as exposition and argumentation, with the frequent writing of short and long themes, and occasional oral debates. The study of English and American literature will receive some attention, but the work will be mainly to illustrate ideal exposition and argumentation. A part of one term will be given to the criticism of the language of technical literature as found in scientific journals.

Sophomore year, five hours a week throughout the year, General Science Course.

Texts: Baker, *Argumentation;*
Baldwin, *Exposition;*
Richard, *The Criticism of Technical Literature.*

MODERN LANGUAGES.

MR. WILKINS.

The great quantity and worth of the technical literature in the French and German languages, added to their value as elements of liberal culture, make at least a reading knowledge of them practically a necessary part of an engineer's education.

The instruction in each language is designed to present the grammatical structure and the pronunciation of the tongue —to give some acquaintance with the masterpieces of its literature, and to confer such facility in translation as will enable the student to read with ease the language in both its literary and its scientific uses.

German (Elementary).—For such students who elect German as the foreign language in their course, and who have not had at least one year of high school German.

Freshman year, second and third terms, four hours per week.

German (Scientific).

Text: Dippold, *Scientific German Reader,* and current scientific journals and magazines.

Sophomore year, five hours per week throughout the year.

French (Scientific).—Students who have not had Elementary French will not be permitted to elect this language.

Text: Herdler, *Scientific French Reader,* and current scientific journals and magazines.

Sophomore year, five hours per week throughout the year.

Spanish.—The growing demand for mining engineers and metallurgists in South and Central America, in Mexico, and in the Philippines, where a knowledge of Spanish is almost an essential qualification, has been met by the establishment of a course in this language in the School of Mines. The natural or conversational method is followed exclusively. The object is to give the student facility in the every-day speech of the people. With the consent of the Faculty, students may elect Spanish as the required modern language.

Text: Hill and Ford, *Spanish Grammar.*

GENERAL INFORMATION.

Terms and Vacation.

The college year, consisting of thirty-six weeks, exclusive of the Christmas holidays, is divided into three terms. The first term begins September 7 and ends December 22; the second term begins January 4 and ends March 12; the third term begins March 14 and ends June 1.

The Christmas holidays intervene between the first and second terms, but there is no interruption of work between the second and third terms. Thanksgiving Day and Washington's Birthday are observed as single holidays.

The Summer School of six weeks begins June 14 and ends July 24, 1909.

Excursions.

The State of Missouri occupies an important place in the mining industry and many opportunities are offered students at the School of Mines and Metallurgy for keeping closely in touch with the mining industry of Missouri and adjoining States. There have been many important developments during the last few years in methods of mining, dressing, and smelting lead and zinc ores. The lead district of southeast Missouri and the zinc district of southwest Missouri offer numerous examples of up-to-date practice in mining and metallurgical engineering. The aggregate tonnage capacity of the concentrating plants of Missouri is greater than that of any other State of the Union. The importance of modern methods of ore dressing is everywhere recognized and the facilities offered by the School of Mines for investigation in ore dressing, together with the practice in concentrating plants which are visited, places the School of Mines and Metallurgy in the foremost rank in this important branch of mine engineering.

Frequent trips and excursions give the student an opportunity to study mining, ore dressing, and metallurgical methods. Field work in metal mine surveying is carried on in suitable mines conveniently located in southeast and southwest Missouri. The practice in coal mine surveying is usually given in one of the northern Missouri coal mines or in the Illinois field.

The Junior class visits southeast Missouri to study the geology, methods of mining, and the milling of great disseminated lead deposits. The geological work of the Junior trip is especially valuable because of the variety of work introduced. The class has an opportunity to study several varieties of pre-Cambrian rocks of igneous and other origin. Differentiation in magma and intrusions can be seen. The pre-Cambrian topography is discernible in relation to the contact plane between the pre-Cambrian and the Cambrian. Evidence of superimposed drainage is offered. Iron ores of Shepard Mountain, Pilot Knob, and Iron Mountain give interesting study in the distribution and origin of ores. The general relation of the lead ores of the Paleozoic is also studied. The weathering of various kinds of rock in conjunction with joining and stratification is well illustrated. The Carboniferous basin about St. Louis is given a brief examination. The student should be provided with note-book, compass, clinometer, hammer, and magnifying glass. The observation work of the day is supplemented by evening conferences.

The concentrating plants of southeast Missouri are large and modern, containing crushers, rolls, elevating machinery, Wilfley tables, Frue vanners, jigs, and sundry other machines. The mining plants are thoroughly modern and include steam and electric hoists, modern steel head-frames, compressed air, and electric haulage, extensive pumping-plants, and numerous diamond-drill prospecting equipments.

In southwest Missouri the geology, mining, and milling of the shallow deposits as well as of 'sheet' ground are studied by the Seniors. Opportunity is given to inspect and study the various types of equipment and methods as adapted to shallow and deeper mining. Many new concentrating plants have been erected and are strictly modern in design and equipment. The application of electric power to mining and milling is well illustrated in this district. Short trips are made to neighboring camps in southeastern Kansas.

Special attention is paid on these trips to general engineering problems, plant design, economy of operation, and organization.

During the Senior year several trips are made to the metallurgical plants in the vicinity of St. Louis. The plant of the St. Louis Blast Furnace Company illustrates blast-furnace practice. Here may be studied the blast-furnace, regenerative stoves, blowing machinery, power plant, and other appliances necessary for the production of pig iron. Open-hearth steel methods and the manufacture of steel castings is studied at the Scullin & Gallagher Works. This plant includes in addition to the usual type of open-hearth furnace, Bessemer converters, cupolas, and gas-producers.

The metallurgy of zinc is studied at the Edgar Zinc Works at Carondelet, where the roasting of blende and distillation methods may be seen. The Federal smelter, at Alton, is visited for the study of lead smelting. At this plant the lead blast-furnace, the Huntington-Heberlein roasting system, and the Scotch ore-hearths are carefully inspected. This plant also includes an extensive bag-house. The manufacture of white-lead paint and of lead pipe is seen at the National Lead Works. A further study of lead smelting is made at Herculaneum, where blast-furnaces are served by Savelsberg pot roasters. At the various plants enumerated, particular attention is paid to the construction of furnaces, the operation of the plant, and the general organization and design.

The manufacture of refractory materials is carefully followed from the mine to the finished product at the plant of the Laclede-Christy Company. This plant is one of the largest clay manufacturing works in the world, and a metallurgist here has a splendid opportunity to investigate refractory products and materials used in the construction of furnaces, stacks, retorts, and crucibles.

These excursions are a required part of the courses and no substitutions are allowed. Every candidate for a degree must take the prescribed excursions as scheduled.

Student Organizations.

The following chapters of college fraternities exist at the School: Gamma Chi of Sigma Nu, Beta Alpha of Kappa Alpha, Beta Chi of Kappa Sigma, Alpha Kappa of Pi Kappa Alpha, and Missouri Beta of Tau Beta Pi.

The Young Men's Christian Association was organized in the College several years ago, and is growing rapidly. It stands for the best there is in college life and brings together those who believe that college men should develop well-rounded characters, physical, mental, and spiritual. During the opening days of the college, trains are met by association members, who place themselves at the service of the new men, helping them to secure rooms and board and to matriculate. The Association occupies the second floor of the Mining Building, where all students are welcomed and regular meetings are held.

The School of Mines Band furnishes music for athletic and outdoor functions and maintains a splendid organization.

The School of Mines Orchestra is reputed throughout south central Missouri as without equal and furnishes music for all School entertainments, the Commencement Exercises and gives concerts in nearby towns.

Other Student Organizations include the Glee Club, the Mandolin Club, the Mathematical Club, and the International Club.

The student body publishes a year-book called 'The Rollamo.' The purpose of this volume is to record the student activities and to present a review of college life at Rolla.

Athletics.

The School encourages rational athletics and has provided an instructor in physical training who has entire supervision of the physical training of students and of all intercollegiate sports. Occasional privileges are granted to athletic teams, but prolonged absences from work are not permitted.

An athletic field has been enclosed and graded for baseball, football, and other games, and an ample number of tennis courts have been laid out, and are maintained in good order. Suitable dressing-rooms and shower baths are provided in a temporary building on the athletic field. A gymnasium is provided on the second floor of Mechanical Hall. Suitable gymnasium apparatus is supplied and indoor games can be carried on during the winter months. A general athletic association exists among the students, also football and baseball teams, and a tennis club.

Athletic Fee.—Each student is requested to pay a fee of Five Dollars to the Athletic Association of the School.

Expenses.

Tuition Fee.—Tuition is free to all students who are residents of Missouri. At a meeting held in October, 1908, the Board of Curators voted that "From and after September 1, 1909, non-residents of Missouri who matriculate in any Department of the University be required to pay a tuition fee of $20 per year."

Laboratory Fees.—The fees charged are as follows: A Library fee of $5 per year, payable upon entrance; a laboratory fee in general chemistry to cover the cost of gas and supplies; $3 per term for all courses except Metallurgy and Special Mining, for which courses the fee is $10; a laboratory fee in qualitative analysis of $7.50 per term to cover the cost of general supplies and gas; a laboratory fee for quantitative analysis and other Senior and Junior chemical laboratory work, $1.75 per term; a fee of $2.50 per term to cover the cost of supplies for shop work; a fee of $2 per term to cover the cost of supplies in forge work; a laboratory fee of $12.50 per term to cover the cost of supplies in assaying; a laboratory fee of $3 per term to cover the cost of supplies in mineralogy; a fee of $5 per term for Senior metallurgy laboratory; a fee of $2.50 per term for mining machinery laboratory.

Contingent Deposits.—Deposits to cover the cost of extra supplies and damage to apparatus are required of the different classmen as follows: Freshmen, $10; Sophomores, Juniors, and Seniors, $15. These deposits must be renewed if at any time exhausted, and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

Living Expenses.—The expenses of many students for the entire year do not exceed $250, which will cover in a reasonable manner the fees, cost of books and stationery, board and lodging, and laundry. The cost of field excursions is not included in the above estimate.

Excursion Expenses.—The cost of field excursions will average about $35 per year.

BUREAU OF GEOLOGY AND MINES.

The Geological Survey of the State of Missouri has its quarters at the School of Mines and occupies the east half of the Rolla Building.

BOARD OF MANAGERS.

Governor Herbert S. Hadley, ex-officio; Professor E. M. Shepard, Springfield; Elias S. Gatch, St. Louis; L. F. Cottey, Edina; C. L. Whitener, Fredericktown.

OFFICERS OF THE GEOLOGICAL SURVEY.

H. A. Buehler, State Geologist.

Equipment.

The Survey has well equipped quarters in the Rolla Building on the School of Mines campus and is furnished heat and light by the School.

The Survey has under its control at the present time a library of five thousand books and pamphlets bearing on Geological subjects, and a museum collection of nearly six thousand specimens of the various clays, coals, fossils, and other geological products of the State. The Geological Survey carries on systematic field work throughout the State by means of its efficient corps of geologists. Reports of this work are printed for distribution among parties interested. Geological maps of the State and of a number of districts have been prepared.

DEGREES CONFERRED 1908.

Engineer of Mines

Joseph Jarvis Brown, Jr., B. S., 1905.
Gustavus Duncan, C. E., 1874.
James Albert Gregory, B. S., 1905.
Elmer Cooper Heck, B. S., 1905.
Ray Eugene Hoffman, B. S., 1905.

Bachelor of Science (Mine Engineering).

Richard Edward Armstrong,
Charles Armstrong Baker,
Ralph Robert Benedict,
John Hyer Bowles,
George Hewitt Boyer,
Horace Asahel Johnson,
Elston Everett Jones,
George Fred Kellogg,
Felix Anthony Lyneman,
Horace Tharp Mann,
Harold Thomas Mapes,
Ward Barr Mix,
Frederic Arnold Moore,
Edwin Phelps Murray,
Alfred Leo Nye,
John Joseph Sandford,
Miles Sedivy,
Edwin Bryant Thornhill,
Clyde Rex Wood,
Frank Lewis Leonard Wilson.

Bachelor of Science (Civil Engineering).

James Duncan Fowler,
Don Morgan Neer,
Paul Andrew Philippi,
Hyman Zirulick.

Bachelor of Science (General Science).

Boyd Dudley, Jr.,
Charles Lewis French,
Frank William Harper,
Herman Carl Hase,
Dibrell Pryor Hynes.

THESES IN 1908.

Lead Smelting on the Ore Hearth, - - - JOSEPH J. BROWN, JR.

Process of Treating Slimes in Ore Reduction, - GUSTAVUS A. DUNCAN.

Report of the Boquillas Del Carmen Mines, of Coahula, Mexico, JAMES A. GREGORY.

Copper Smelting in a Rotary Furnace with Pulverized Charcoal, ELMER C. HECK.

Square Set Timbering as Employed by the Shannon Copper Company, RAY E. HOFFMAN.

The Mining and Milling of a Low-Grade Copper Ore, HORACE A. JOHNSON AND RICHARD C. ARMSTRONG.

The Effect of Copper on the Cupellation of Silver and Gold, CHARLES A. BAKER AND MILES SEDIVY.

Desulphurizing or Pot Roasting of Lead Ores, RALPH R. BENEDICT, EDWARD P. BARRETT, AND FRANK W. HARPER.

The Effect of Tellurium on the Cupellation of Silver and Gold, HORACE T. MANN, EDWIN P. MURRAY, AND JOHN H. BOWLES.

Test of School of Mines Water and Light Plant, GEORGE H. BOYER, LELAND R. WALKER, AND ALFRED L. NYE.

An Investigation of the Treatment of the Silver Ore by Lixivation of Sodium and Cuprous Thiosulphate Solutions, - ELSTON E. JONES.

Test of Rolla Water and Light Plant, WARD B. MIX, GEORGE F. KELLOGG, CLYDE R. WOOD, AND EDWIN B. THORNHILL.

The Development of a Lead and Zinc Prospect, - FELIX E. LYNEMAN.

Treatment of a Mexican Copper Ore, - HAROLD T. MAPES.

The Effect of Arsenic on the Assay of Gold and Silver Ores, ROSCOE C. HAM AND FREDERICK A. MOORE.

Lime Roasting of a Copper Concentrate and Treatment in the Blast Furnace, - - - FRANK L. L. WILSON.

The Effect of Common Minerals on the Volatilization of Silver Chloride, BOYD DUDLEY, JR.

Geology of the Cambrian-Carboniferous Unconformity in the vicinity of Rolla, - - - DIBRELL P. HYNES.

The Effect of Antimony on the Assay of Gold and Silver Ore, HERMAN C. HASE AND CHARLES L. FRENCH.

Graphical Representation of Compressed Air Formulae, PAUL A. PHILIPPI.

Design of Main Street Reinforced Concrete Arch over Frisco Railroad, HYMAN ZIRULICK.

Design of Water and Power Plant on Little Piney River, FRANK L. FLYNT AND JAMES D. FOWLER.

Design of a Reinforced Arch over Frisco Railroad at Tenth Street, Rolla, Mo., - - - DON M. NEER.

Report on the Shattuck and Arizona Mine, Bisbee, Ariz., JOHN JOSEPH SANDFORD.

GIFTS TO THE SCHOOL OF MINES

Aetna Powder Co	Chicago, Ill.	Cabinet of explosive samples.
American Bridge Co	New York, N. Y.	Two pictures of head frames.
Atchison, Topeka & Santa Fe Ry. Co.	Chicago, Ill.	Framed picture.
Atha Tool Co.	Newark, N J.	Prospecting picks and hammers.
Autolyte Manufacturing Co	New York, N. Y.	Samples of fuse.
Bausch & Lomb Optical Co	Rochester, N. Y.	One skeleton transit for drafting room.
Branham, W. G	Joplin, Mo.	Minerals from Bisbee, Ariz.
Brown Hoisting Machinery Co.	Cleveland, Ohio.	Three framed photographs.
Burdick, C. A.	Dansville, N. Y.	Minerals from Cobalt, Ontario.
California Cap Co	Oakland, Cal.	Literature on blasting.
Carnahan Mfg. Co	Denver, Colo.	Blue-print of rock-drill.
Carnegie Steel Co	Pittsburg, Pa.	Samples of iron and steel.
Chicago Pneumatic Tool Co	Chicago, Ill.	Blue-prints of rock-drills.
DeWaters, R. H	Grant City, Ill	Samples of corn products.
Economic Machinery Co	Denver, Colo	Prints of rock-drills.
Fay, A. H	Brooklyn, N. Y.	Collection of rocks from New York City and vicinity.
Fairbanks, Morse & Co	Denver, Colo.	Blue-print of rock-drill.
Farrell Foundry & Machinery Co	New York, N. Y.	Blue-prints and framed photographs.
Fraser, K. C.	Lyndonville, N Y	Fossils from New York.

Gardner Electric & Machinery Co. . . . . Cleveland, Ohio.
Blue-prints of rock-drills.

Griswold, Professor L. S. . . . . Rolla, Mo.
Ores from Nevada; rocks from Decaturville, Mo.; iron ores from Iron and Shepard Mountains, Mo.; fossils from Gasconade and carboniferous formations near Rolla.

Hase, H. C. . . . . Morenci, Ariz.
Analyzed samples of ore.

Heller Bros . . . . Newark, N. J.
Two bars of drill-steel.

Ingersoll-Rand Co. . . . . New York, N. Y.
Blue-prints of rock-drills.

Jeffrey Mfg. Co... . . . . Columbus, Ohio
Blue-print of rock-drill.

Jones, J. W.. . . . . Webb City, Mo.
Analyzed zinc ores.

Kibe, H. C. . . . . Davenport, Ia.
Copper ore from Northern Ontario, lead and zinc ores from Magdalena Mountains, New Mexico.

Leyner Engineering Works Co. . . . . Littleton, Colo.
Blue-print of rock-drill.

Murphy, B. F. . . . . Bonne Terre, Mo.
Specimens from iron fissure vein in Southeast Missouri.

New York Central Railroad Co. . . . . New York, N. Y.
One picture.

Seamon, W. H. . . . . Chihuahua, Mexico.
Analyzed samples of ore.

Sullivan Machinery Co. . . . . Chicago, Ill.
Two blank bits, two drawings of rock-drills.

Star Electric Fuse Works. . . . . Wilkesbarre, Pa.
Samples of electric explosives.

Stephen Humble. . . . . London, England.
Model of detaching safety hook.

The Ensign-Brickford Co. . . . . Simsbury, Conn.
Samples of mining fuse.

Union Pacific Railroad Co. . . . . St. Louis, Mo.
Framed pictures.

Westinghouse Electric Co. . . . . St. Louis, Mo.
Twenty-five lantern slides.

Wright, J. W. & Co. . . . . St. Louis, Mo.
Pictures of machines.

Zerger, H. F. . . . . Columbia, Pa.
Specimens of chrondodite and garnet.

STUDENTS AT THE MISSOURI SCHOOL OF MINES AND METALLURGY

1908-1909

GRADUATE STUDENTS.

Ambler, John Owen* .... Cananea, Mexico.
B. S. in M. E., 1906, School of Mines.
Burgher, Mark Bernardie* .... Hannibal, Mo.
B. S. in C. E., 1905, School of Mines.
Delano, Lewis Alfred* .... Bonne Terre, Mo.
B. S. in M. E., 1904, School of Mines.
Dudley, Boyd, Jr. .... Rolla, Mo.
B. S. in G. S., 1908, School of Mines.
Forbes, Carroll Ralph .... Topeka, Kans.
E. M., 1903, Michigan College of Mines.
Foster, Leo Joseph* .... Montrose, Colo.
B. S. in M. E., 1904, School of Mines.
Horner, Preston King* .... Ely, Nev.
B. S. in M. E., 1906, School of Mines.
Hunt, Lamar Horatio* .... Mercur, Utah.
B. S. in M. E., 1905, School of Mines.
Hynes, Dibrell Pryor .... Rolla, Mo.
B. S. in G. S., 1908, School of Mines.
Lintecum, Charles Lafayette* .... Telluride, Colo.
B. S. in M. E., 1905, School of Mines.
Long, James Carter .... St. Louis, Mo.
B. S. in M. E., 1907, School of Mines.
Mann, Horace Tharp .... Rolla, Mo.
B. S. in M. E., 1908, School of Mines.
Murray, Edwin Phelps .... Fosterville, Wis.
B. S. in M. E., 1908, School of Mines.
Quinn, Matthew Vincent* .... Quartzburg, Idaho.
B. S. in M. E., 1905, School of Mines.
Rivera, Ramon* .... Guadalajara, Mexico.
B. S. in C. E., 1906, School of Mines.
Rucker, Ray Fleming* .... Hannibal, Mo.
B. S. in M. E., 1906, School of Mines.
Smith, Charles Dosh* .... Webb City, Mo.
B. S. in Chem., and Met. 1905, School of Mines.
Steinmesch, Jesse Herman* .... Desloge, Mo.
B. S. in M. E., 1906, School of Mines.
Wilfley, Clifford Redman* .... Hostotipaquillo, Mexico.
B. S. in M. E., 1906, School of Mines.

*In Absentia.

SENIORS.

Anderson, Hector George Sylvester	Vancouver, B. C.
Barrett, Edward Phillip	Hastings, Neb.
Baueris, William Albert	Chicago, Ill.
Beard, John Warren (C. E. Syracuse University)	Syracuse, N. Y.
Boyer, Fred Tete	St. Louis, Mo.
Butler, Reginald Henry Brinton	South Woodford, England.
Cavazos, Enrique	Saltillo, Mexico.
Chamberlain, Ernst Lorenz	Rolla, Mo.
Clark, William Newton	Jewell City, Kans.
Clarke, William Danels	Rolla, Mo.
Compton, James Crawford	Independence, Mo.
Dobbins, Walter	Urbana, Ill.
Don, DeForrest	Rock Island, Ill.
Dunn, Theodore Saunders	Waukegan, Ill.
Easley, George Albert	Walker, Mo.
Elicano, Victoriano	Masinloc, Zambales, P. I.
Garst, Harvey Oden	Cabool, Mo.
Hall, William Simpson	Independence, Kans.
Ham, Roscoe Conkling	Kansas City, Mo.
Hinsch, Van Buren	Davenport, Iowa.
Hughes, Victor Harmon	Sabetha, Kans.
Illinski, Alexis Xavier	Nashville, Tenn.
Jochamowitz, Simon (E. M., School of Mines of Peru)	Lima, Peru.
Keniston, Carl Winthrop	Plymouth, N. H.
Kibe, Harry Clay	Davenport, Iowa.
Ladd, Hammond	Rolla, Mo.
Leming, Paul Bauchmann	Cape Girardeau, Mo.
Loveridge, Frank Richard	Rochester, N. Y.
McCrae, Rowe Francis	Rolla, Mo.
McElroy, William	Fort Scott, Kans.
Mazany, Mark Stephen	Dunkirk, N. Y.
Michael, Pearl Frederick	Rolla, Mo.
Nachtman, Frank	Junction City, Kans.
Ohnsorg, Norman Lloyd	Rolla, Mo.
Pollard, Arthur Lewis	Batavia, N. Y.
Shah, Aaron Max	Vilna, Russia.
Smith, Earl McColloch	Little Rock, Ark.
Walker, Leland Ross	St. Louis, Mo.
Watson, Ralph Wilheim	Salt Lake City, Utah.
Wishon, Albert Emory	Fresno, Cal.
Wolf, Edgar Joseph	Mt. Vernon, Ind.

JUNIORS.

Allen, Robert Sexton	Kansas City, Mo.
Andrews, Sanford William, Jr.	Arcadia, Mo.
Blake, Frank Orris, Jr.	St. Louis, Mo.
Blaylock, Daniel Webster	Flat River, Mo.
Bodman, John Whittlesay	Kansas City, Mo.
Boland, Earl Frederick	Syracuse, N. Y.
Bowles, James Joseph	Lake Springs, Mo.
Branham, William Grover	Joplin, Mo.
Bunten, James	Canon City, Colo.
Burdick, Charles Adrian	Dansville, N. Y.
Callaway, Scott David	Nevada, Mo.
Caples, Russell Bigelow	Glasgow, Mo.
Clark, John Charles	Chicago, Ill.
Connelly, Harry Wade	Independence, Kans.
Detweiler, Alfred Nicks	Lebanon, Mo.
Detweiler, Milan Harrison	Lebanon, Mo.
Diaz, Emilio	Santiago, Chili.
Dosenbach, Benjamin Harrison	St. Louis, Mo.
Farrar, Monroe	Mattoon, Ill.
Forman, John Kavenaugh	McFall, Mo.
Fraser, Keith Colt	Lyndonville, N. Y.
Gray, Howard Dean	Wausem, Ohio.
Gregory, Clay, Jr	Joplin, Mo.
Haataja, Charles Leo	Helsingfors, Finland.
Harlan, John Dee	Moberly, Mo.
Harrison, Walter Edward	Salem, Mo.
Holmes, Oliver Wendell	Rolla, Mo.
Jobes, Charles Taylor	Kansas City, Mo.
Judy, Philip Smith	Camp Point, Ill.
Karte, Anton Frederick	De Soto, Mo.
Kenney, John Richardson	Chicago, Ill.
Killian, Ralph Daniel	Perryville, Mo.
List, Elmer	Cape Girardeau, Mo.
McColloms, Max Reed	Newton, Iowa.
McNutt, Vachel Harry	Monroe City, Mo.
Mackey, Robert William	Waukegan, Ill.
Miller, Christian R., Jr	Sedalia, Mo.
Minor, Harmon Edwin	Canon City, Colo.
Mook, Robert Lee	St. Louis, Mo.
Morgan, Allen Ray Dearborn	Rolla, Mo.
Murphy, Benton Franklin	Bonne Terre, Mo.
Park, Albert	Rolla, Mo.
Peterson, Howard Kelsey	New Rochelle, N. Y.
Pickering, John Lyle, Jr	Springfield, Ill.
Pierce, Colwell Arba	Kansas City, Mo.

Porri, Louis Joseph	St. Louis, Mo.
Porth, Harry William	Kansas City, Mo.
Radovich, John Christopher	Bisbee, Ariz.
Riede, Fred Edward	Canon City, Colo.
Schmidt, Sidney Randolph	Chicago, Ill.
Schultz, John Elmer	Topeka, Kans.
Shaw, Albert Henry	St. Louis, Mo.
Smith, Duncan Slater	Rockford, Ill.
Smith, Harvey Edson	St. Louis, Mo.
Smith, Van Hoose	Little Rock, Ark.
Stewart, John Sloane, Jr.	Mansfield, Ohio.
Thompson, Reuben Conrad	Sioux Falls, S. D.
Thornberry, Martin Harmon	Rolla, Mo.
Traughber, Charles Weaver	Centralia, Mo.
Twyman, George Thomas, Jr.	Independence, Mo.
Vogt, George C.	Davenport, Iowa.
Welsh, Harold Llewellyn	Kansas City, Mo.

SOPHOMORES.

Abbott, Edward Reese	Mansfield, Ohio.
Abernathy, George Elmer	Willow Springs, Mo
Adams, Henry Farnum	Prescott, Ariz.
Albertson, Maurice Merton	Aurora, Mo.
Allen, Ernest James	Forrest, Ill.
Beach, James Keller	Kansas City, Mo.
Bingham, Raymond Alexander	Watertown, Mass.
Blake, True Walter	Maywood, Ill.
Boza, Hector	Lima, Peru.
Bradt, Albert Leonard	St. Louis, Mo.
Chase, James Howard	Logansport, Ind.
Coaske, Paul Ephraim	St. Louis, Mo.
Cody, Benjamin Horace	St. Joseph, Mo.
Coover, Louie Lincoln	Springfield, Mo.
Copeland, Robert Nathaniel	Chelsea, Mass.
Elmore, Carlos	Lima, Peru.
Engelmann, Edward William	St. Louis, Mo.
Fey, Don Frederick	Burlington, Iowa.
Flynn, Frank James	St. Joseph, Mo.
Ford, Harold Percy	St. Joseph, Mo.
Forrester, David Lawton	Oakland, Cal.
Garcia, Herman	Mexico City, Mex.
Gosrow, Ralfe Cleveland	Buffalo, N. Y.
Grosberg, Alex	St. Louis, Mo.
Groves, Frank W.	Des Moines, Iowa.
Harris, Deane Dwight	Rolla, Mo.

Holm, William Miller	Chicago, Ill.
Jones, Howard Hiltz	Kansas City, Mo.
Kline, Duane Montgomery	Rolla, Mo.
Kurz, Adolph	St. Louis, Mo.
Lamadrid, John Manuel	Sancti Spiritus, Cuba.
Lunak, Otto Allen	St. Louis, Mo.
McElherne, James Charles	Rock Island, Ill.
Macomber, Sumner Cooley	Des Moines, Iowa.
Mann, Frank Clark	Springfield, Mo.
Mitchell, Robert Bruce	Walker, Mo.
Nachtman, Ralph	Junction City, Kans.
Nason, Stanley Lewis	West Haven, Conn.
Ormsby, Robert Graham, Jr.	Kansas City, Mo.
Overstreet, Chester Zearl	Indianapolis, Ind.
Pudewa, Arthur Gustav	Chicago, Ill.
Raj, Shiv	Lahore, India.
Randolph, Oscar Alan	Kansas City, Mo.
Scoates, Richard	South Milwaukee, Wis.
Strong, Arthur Leon	Lyons, Mich.
Stroup, Thomas Andrew	Lewistown, Mo.
Tedrow, Harvey Louis	St. Joseph, Mo.
Townsend, Frank Edgar	Belgrade, Mo.
Williams, Conway Guild	Jackson, Mo.
Wolf, Harold Max	Mt. Vernon, Ind.
Zimmerman, George Henry	Romney, W. Va.

FRESHMEN.

Bilderback, Alexander Scott	Kansas City, Mo.
Blake, Harold	St. Louis, Mo.
Bland, John Lilburn	Lebanon, Mo.
Bower, Albert	Mattoon, Ill.
Bowles, Rupert	Durant, Okla.
Bribach, Oscar Nicholas	St. Louis, Mo.
Broughton, Eugene Harding	Jefferson City, Mo.
Castillon, Tirso	Torreon, Mexico.
Conover, Cairy C.	Carrollton, Mo.
Cronk, Arthur Harrison	Omaha, Neb.
Cushwa, Claude Calvin	Independence, Mo.
Deacon, Arthur P.	Webster Groves, Mo.
Diaz, Washington Theodore	Santiago, Chili.
Dunkin, John Haskell	Guthrie, Okla.
Durkee, J. B.	Kansas City, Mo.
Elbert, William	St. Joseph, Mo.
Farrell, Oliver	St. Louis, Mo.
Gray, Walter Berry	Louisiana, Mo.

Greensweight, Robert	Rolla, Mo.
Hackwood, Arthur Willesley	Baxter Springs, Kans.
Hayes, Dale Irwin	Rock Island, Ill.
High, Howard Herman	Faulkner, Kans.
Hollister, Scoville Edward	Marshall, Mo.
Houseknecht, Seward Forward	Batavia, N. Y.
Irwin, Joseph Stewart	Louisiana, Mo.
Johnston, Mead	Okmulgee, Okla.
Kerr, Andre Joseph	St. Louis, Mo.
Kinney, Robert Noel	Rolla, Mo.
Kranzthor, Fred Otto	Eagle Pass, Texas.
Leavitt, James Blaine	Washington, D. C.
Lynton, Edward	Ipswich, England.
Lyons, Clyde Francis	Springfield, Mo.
McFadden, Edwin Cook	Chicago, Ill.
McKibben, Harold Dennis	Kansas City, Mo.
McNair, Stuart Strathy	New York City.
Meeker, Samuel Ezra	Pekin, Ill.
Michelsen, Thomas Henry, Jr.	Hobart, Ind.
Morris, Edwin Robinson	Jefferson City, Mo.
Myers, Warren Prescott	Prescott, Ariz.
Naylor, Arch Waugh	Marshall, Mo.
Newton, Lloyd Charles	Gurdon, Ark.
Parent, George Lee	Marshall, Mo.
Plessner, Albert	Holden, Mo.
Porri, William	St. Louis, Mo.
Porter, Jerome	Hannibal, Mo.
Purcell, Robert Crofts	St. Louis, Mo.
Rachal, Frank C.	Falfurris, Texas.
Radcliffe, Donald Hewson	St. Louis, Mo.
Raible, Norman William	Hannibal, Mo.
Robinson, Eugene Charles	Independence, Mo.
Royden, Frank Applegate	Edgewood, Iowa.
Runnels, Ralph Willard	Kansas City, Mo.
Schilling, George William	Freeport, Ill.
Schmich, Matt	Freeport, Ill.
Shaw, Harry	St. Louis, Mo.
Shaw, Thomas Edward	West Haven, Conn.
Sherry, Homer Kent	Lyndon, Kans.
Smith, Marshall Raymond	Rolla, Mo.
Smith, William Bryce	Baxter Springs, Kans.
Stephenson, William Pittman	Nevada, Mo.
Sudhoff, Ralph William	Richmond, Ind.
Thomas, George Sylvester	Chicago, Ill.
Trenkel, Willie Max	Rolla, Mo.
Tway, Robert Raymond	Springfield, Mo.

Ustick, Edward Thomas	St. Louis, Mo.
Vanderhoff, Ralph Scovell	Vandalia, Ill.
Wafer, James Oscar	Greenville, Ill.
Wemhaner, Oscar Christopher	Warsaw, Ill.
Wright, Oscar Conway	St. Louis, Mo.
Yelton, Erastus	Rolla, Mo.

SPECIALS.

Chowning, James William	St. Louis, Mo.
Fort, Albert Sidney	Rolla, Mo.
Hanes, James Edward	Wheeling, W. Va.
Hauber, Ben	Springfield, Mo.
Heydecker, Coral T	Waukegan, Ill.
Johnesee, Frank	Greenfield, Ill.
Jones, William Hamilton	St. Louis, Mo.
Martin, Harry H.	Fredericktown, Mo.
Owen, Harvey Skidmore	St. Louis, Mo.
Siegmund, Walter Finney	St. Louis, Mo.
Wright, Clark Watson	St. Louis, Mo.

ENROLLMENT BY STATES AND COUNTRIES.

Arizona	3
Arkansas	2
California	2
Colorado	5
Connecticut	2
District of Columbia	1
Idaho	2
Illinois	29
Indiana	6
Iowa	7
Kansas	13
Massachusetts	2
Michigan	1
Missouri	128
Nebraska	2
Nevada	1
New Hampshire	1
New York	12
Ohio	3
Oklahoma	3
South Dakota	1
Tennessee	1
Texas	2
Utah	2
West Virginia	2
Wisconsin	2
British Columbia	1
Chili	2
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EDUCATION FOR UTILITY AND CULTURE*

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Dean of the School of Engineering and Architecture of Washington University.

The early Universities came into being as a part of the grand revival which prevailed in Italy, Germany, France, and England in the 14th and 15th centuries. They were the joint product of Protestantism and the art of printing. The former declared it the privilege of all to read the New Testament and the Fathers in the original Greek and Latin. The art of printing laid open to all the world all the treasures of ancient learning.

Oxford and Cambridge came into notice about the year 1300, and for some four centuries they were the recipients of repeated gifts and benefactions from the rulers and the nobility of England. As the Universities grew the course of study slowly expanded. In the beginning they were largely Latin Grammar Schools for monks and priests. Even in Queen Elizabeth's time Oxford was little more than a Divinity School. Undergraduates were fourteen or fifteen years of age and often younger. The *Trivium* leading to the degree of Bachelor of Arts consisted of Latin Grammar, Logic, and Rhetoric. There was no Greek until the time of Erasmus in 1511. Even a Latin version of Aristotle's Logic was used.

Having completed three years in the study and practice of Dialectics, the student became a Bachelor of Arts and "incepted" or "commenced" the four years of study of the *Quadrivium* which lead to the degree of Master of Arts.

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*An address delivered before the students of the School of Mines and Metallurgy, June 8, 1909, under the auspices of Tau Beta Pi.

The ceremony of Commencement took place naturally at the beginning of the fourth year, when the student received his first degree and entered upon the higher course of study. The Master's degree was conferred at the end of the seventh year. You will observe that we have retained the name "Commencement" to mark the termination of the first course, and not at all to signify the beginning of the Master's course; and that the ceremony is held at the beginning of the summer vacation instead of at its end, as formerly.

The Quadrivium included: 1. Arithmetic or the science of numbers (there was for 300 years afterward no Algebra, no Trigonometry, no Analytic Geometry, no Calculus); 2. Geometry, *i. e.* Euclid and maps, which included all the geography which was known; 3. Music; 4. Astronomy, as taught by Ptolemy.

No poets or orators were studied at Cambridge till the early part of the 16th Century. Their introduction was due to Erasmus, who came to St. John's College in 1511. During the Chancellorship of Thomas Cromwell in the reign of Henry VIII., it was ordered that undergraduates should be instructed in Logic, Rhetoric, Arithmetic, Geography, Music, and Aristotle. In 1549 the Trivium was changed to Mathematics, Dialects, and Philosophy; the Quadrivium to more Philosophy, Perspective Drawing, Astronomy, and Greek.

Such was the course of study that for centuries constituted the education of the generous youth of England who were destined to fill the places in the church, to become barristers, physicians, or gentlemen of leisure. For such and such only was education supposed to be necessary.

In his famous Tractate on Education, written twenty-four years after the landing of the Pilgrims on Plymouth Rock, Milton wrote only for the rich and for those of noble birth. He advised the study of the Poets, Orators, Historians, and Philosophers of Greece and Rome. There was little else for them to study. There was no science, for the speculations of Aristotle in regard to Physics and the constitution of matter were unworthy of the name of Science though they blocked all scientific progress for over a thousand years. English literature did not exist. Modern Mathematics is the product of the last two hundred years. Milton himself followed in the tracks of Virgil, as Virgil had followed in the track of Homer. "Paradise Lost" was modeled after the Aeneid; the Lycidas closely resembles one of the Bucolics of Virgil.

Milton wrote and sang for the few. The great bulk of the English people, the farmers, the sailors, the miners, the tradesmen, the manufacturers, the builders of houses and ships, had no education and they were supposed to need none. Popular, universal education as we understand the term is less than forty years old in England. During all these years while England has been growing great, Cambridge and Oxford built on the lines I have described. They had a monopoly of the education of the English ruling and property classes. No men trained differently were brought into competition with them, and hence the claim that is often made, that the greatness of England's great men is due to the fact that their training was classical rather than scientific is extremely illogical. No one denies great intellectual value to ancient as well as to modern classics, but we have learned that men may be educated in more than one way; that the old road is a long road, a comparatively dull and uninteresting road; a road blocked up by dead issues, ancient ruins, over the graves of extinct nations, and through an atmosphere redolent with the airs of antiquated myths. The classical period was a civilization of art and luxurious culture based on conquest and human slavery. And such as I have described was the old University, and such in many institutions is the ideal today. But all such must be classed with the ancients. It is their glory to be old, as though age in itself was a virtue.

I visited an endowed school in Manchester, England, a few years ago. It was hundreds of years old. It had its ancient halls, its ancient studies, its impassable fence, and its locked gates. But gradually its style of household furniture had become transformed. A modern kitchen, a new dinner service, carpets and chairs reminded one of modern life. Then the craze for antiquity swept over the Board of Management and they decided to put the school back two hundred years and to return to the actual style of living in "the good old times." Out went the carpets, the cooking stove, the dining table; off went the table-cloth and modern spoons and forks; modern chairs, napkins, and plates. The pupils adopted again the ancient dress; they cooked on spits and behind tin ovens over open fires in huge fire places; they sat on benches without backs, at a rough oak table above a stone floor, and ate from pewter plates and drank from pewter mugs. Grace was said in Latin before and after the meat. I assure you it seemed to me like a grand burlesque for the presentation of which a hundred little boys were being trained to act their parts.

In striking contrast with all this reminder and mockery of antiquity, was a modern manual training room with the best of modern tools and appliances. This latter was the gift of an enthusiastic friend who thus redeemed and modernized the entire school.

Up to sixty years ago honors at Cambridge were awarded only in Classics and Mathematics. In 1848 two new "Triposes", or honors, were established, viz.: in Moral Science and in Natural Science. Then came the Law Tripos, the Historical Tripos, the Theological Tripos, the Semitic Languages Tripos, the Indian Languages Tripos, and finally, the Modern Languages Tripos in 1886.

During the last few years Mechanical and Electrical Engineering have gained a foothold in Cambridge and recently they have been placed on a permanent footing. A manual training shop has even secured recognition among the "modern side" people of Cambridge.

The introduction of the study of Elasticity into physical and engineering problems marked a great advance. Up to the middle of the last century, teachers and writers reasoned about solids as though they were rigid bodies. The ultimate strength of a bar or a beam, was the only thing considered. The laws which pertain to internal stress were unknown and hence ignored. The distinction between external and internal forces in a structure or a mechanism strangely enough marked the difference between pure science and applied science or engineering. What would bridge engineering, mechanical and electrical engineering be without the doctrines of internal stress, and elastic limits?

Higher education in the United States started on a somewhat different plane and it has had a very different development. When Harvard College was started two hundred and sixty years ago, it was a feeble imitation of one of the Colleges of Cambridge University in England where John Harvard had been a student, but there was in every New England village a school where the rudiments of an education were accessible to all. In those days Harvard College was what would now be called a classical high school. It was pre-eminently a school for the preliminary training of ministers of the Gospel and for lawyers. It was Latin, Greek, Mathematics, Logic, Rhetoric, and Metaphysics from first to last. The course of study had not changed in character very much when I was a student there fifty years ago, but a wonderful transformation has now taken place.

The study of materials; the study of the laws of construction, the distribution of forces, the analysis and limits of internal stress, the transformation and utilization of energy; the study and use of exact methods and instruments of precision; the elements of drafting, shopwork, and the essential features of prime movers;—all these studies have made this progress possible, and they promise yet greater progress, if the proper education is furnished.

We are at last beginning to understand that the education that is to be universal should be a very different thing from the education of a privileged few. The new education which dominates the modern colleges and universities aims to train men to high efficiency along all lines, practical, theoretical, as well as artistic and spiritual. The old procrustean bed on which all were stretched or trained to the same course of study has been banished, never to return. The characteristic feature of the new University is freedom of choice and a thoroughly practical treatment of the chosen branches.

A university is a place where one should be able to study the best that has been said and done in the world. In our secondary schools one may acquire the rudiments of an education, may learn how to study, may become somewhat familiar with the breadth and scope of the objects of study; but in the University he should directly attack the masterpieces of thought and achievement; should dip into the choicest and most invigorating springs and drink deeply.

From the days of John Milton, in 1608, to the end of the 18th century, university training culminated in a preparation for the professions of law, medicine, and theology, and in the training of the nobility for the duties and responsibilities of government and elegant society.

But when alchemy developed into chemistry; when physics became an experimental science; when Leibnitz and Newton elaborated the infinitesimal calculus; when Watts invented an efficient steam engine; when Fulton built a successful steamboat; when Stephenson devised the locomotive and constructed a road with smooth rails; and finally when Siemens and Gramme produced the electric motor—vast fields of fascinating and useful material were opened for study and research. Mathematical analysis and the principles of mechanics which had previously been devoted to the problems of physical astronomy, were now directed to the study of the transformation and transmission of energy, the theory of structures, and the phenomena of electricity. The theory of evolution has given a new meaning to all vital phenomena; and the doctrine of the conservation of energy has permeated all our study of motion and force.

In the earlier days Alexander Pope voiced the popular notion that "The proper study of mankind is man." "Nature Study," which today is the bright attractive feature of the primary school, and equally the inspiring field of the savant, was not countenanced by polite society. For centuries it was held to be little short of blasphemy to wound the earth by digging for ores which were intended to be hidden away from our sight and touch; or to attempt in any way to improve upon God's workmanship. When in 1680 a Spanish engineer proposed to deepen the channels of certain rivers and to restrain their overflows in the interest of navigation, the Spanish Council decreed as follows: "If it had pleased God that those rivers should have been navigable, He would not have needed human assistance to make them so; but as He has not done it, it is plain that he does not want it done;" and the improvements were forbidden.

Again when Peter the Great, the founder and source of Russian greatness, proposed to unite by a canal the Don, one of the largest rivers which flow into the Black Sea, with the Volga, the largest river which flows into the Caspian Sea, at a point where they are only a few miles apart, in order that the commerce of the Caspian might have an outlet to the ocean, he was successfully opposed by the Church whose dignitaries held that to connect those two rivers would be displeasing to God, who had planned to keep them apart.

It has taken many centuries for the world to discover that the great forces of nature are neither sacred nor profane, neither kind nor cruel, that they neither love nor hate, and that they are more unchangeable than the stars; that shrines and temples, priests and priestesses, tripods and oracles have been in vain except so far as they reacted upon the human heart and satisfied its natural craving for the worship of a

Superior Being. Instead of building a temple to the far-darting Apollo or to Zeus the Thunderer, we now stretch over our cities a net-work for artificial lightning; and all the winds that blow and all the waters that flow are made to furnish their tribute to our comfort and pleasure. We tap the sources of endless energy and transmit it through all the ramifications of our social order, relieving mankind from heavy burdens and creating hundreds of occupations hitherto all unknown.

Out of this vast extension of the horizon of human activities, and this multiplication of occupations, has come an imperative demand for technically educated men. In our industrial system the crying want has been and is for men who can both plan and execute. The secret of our recent success in foreign markets lies in the fact that we have put educated brains into our products and into our methods of manufacture. Hence a score of professions unthought-of 100 years ago, have been called into being, and the standards of these new professions are intellectually not one whit lower or less humane than the old.

Our best preparation for the future is the mastery of what has already been achieved. Our undergraduate period should be devoted to the study and mastery of established truths and accomplished facts, as embodied in language, literature, and the achievements in the arts and sciences. As Matthew Arnold put it: "The student should study the best that has been said and done in the world." I like Arnold's statement exceedingly, if I can only make it broad enough to include the wonderful results of applied science during the last hundred years. I am one of those who believe in progress, in the superiority of our own age; I regard the conquests over matter and force through intellectual processes of the highest order, as among the best things that have been done in the world, and I include what has been discovered and well established in the realm of natural history and applied art, as well as in the realm of ethnology and sociology.

The world has been slow to accept the dignity of a scholarship for service. The old idea of culture was, not that which enables one to accomplish something for others, but that which was valued for what it was supposed to accomplish for one's self,—as Emerson puts it.

It is interesting to note how strong and enduring has been the prejudice against any scholarship that was suspected of being useful. Among the Greeks and Romans of the classic period, it was held to be not only undignified but ignoble to personally provide food, clothing, and shelter for one's self or for one's family. The educated man must not build his home, nor even plan it. He must neither cultivate crops nor cook his food; neither manufacture cloth, nor make garments. All such work was for slaves, white, black, or yellow.

It was the business or occupation of the gentleman, (who alone received any education), to manage his family (including his slaves), fight for his country whether for conquest or for defence, cultivate art, poetry, athletics, mathematics, and logic. Even Plato considered geometry as degraded by being applied to any purpose of vulgar utility. He declared that the construction of machines on mathematical principles was reducing a noble intellectual exercise to a low craft, fit only for carpenters and wheelwrights, *i. e.,* for the white slaves of Athens. He held that the science of Mechanics was unworthy of the attention of a philosopher. For nearly two thousand years the brightest minds of Greece and Rome scorned utility, and they discouraged all studies which aimed "to add to the comfort or alleviate the calamities of the human race." Macauley says (in his Essay on Bacon) that Seneca was indignant that Democritus was praised for having invented the arches which supported the roof of a temple. He maintained that Philosophy has nothing to do with teaching men to rear arched roofs over their heads. The true philosopher, he said, does not care whether he has an arched roof, or any roof. Philosophy has nothing to do with teaching men the use of metals. She teaches us to be independent of all material substances, of all mechanical contrivances. Instead of attempting to add to the physical comforts of his species, Seneca regretted that his lot was not cast in that golden age when the human race lived in caves and dressed only in the skins of animals. To impute to such a man any share in the invention or improvement of a plow, or a mill, is an insult. "In my time," says Seneca, "there have been inventions of this sort, transparent windows, tubes for diffusing warmth equally through all parts of a building, etc., but the invention of such things is drudgery for the lowest slaves. Philosophy lies deeper. It is not her office to teach men how to use their hands."

Bacon set out deliberately to overthrow the influence of Greek philosophy as regards usefulness, and with unequaled force and skill proclaimed the dignity and nobility of useful studies, and of service to humanity. I feel sure that the spirit of service through the discovery and presentation of scientific truth lives and thrives, and that nevermore will it be necessary, at least in America, for a man of science to apologize to the world for making his discoveries and inventions useful to mankind.

We have been told that engineering studies and pursuits make men sordid and narrow. The statement is not true. It is true that such studies make one feel the weight of coming responsibilities, as well as the absolute necessity of mastering fundamental principles. Engineering students rarely feel at liberty to burn their old text-books. They have been thought to be somewhat lacking in reverence, and unpoetical. I must confess that they are generally not given to the worship of the Ancients, but they are not without poetic instincts.

Do not for one moment suppose that all knowledge is contained in books, or that all art is to be found in museums, or that all poetry is written with pens. To a mind filled with a sympathy that is born of intimate knowledge, there is in a mighty moving mechanism, and in the proportions and grandeur of a great superstructure that obeys all the laws of science, a beauty which delights the eye, a harmony and bond of thought, a rhythm and rhyme of reason that falls upon the inward ear like heavenly music.

Naturally the first engineers were military, as the earliest functions of organized society were those of attack and defence. But when nations began to learn the arts of peace and fixed public works became necessary, the civil engineer, as distinguished from the military and the naval engineer, came into being. During the last fifty years civil engineering has been differentiated and has thrown off as distinct departments, mining engineering, mechanical engineering, and electrical engineering. Still more recently each one of these in actual practice has been subdivided many times, as the necessity has arisen, and as special lines of research and experience have been opened. At present it is the civil engineer who designs and constructs our railways, whether in our streets, underground, or overhead, across our prairies or among the mountains; he constructs our bridges and tunnels; our canals and locks; our lighthouses, break-waters and jetties; our dams, reservoirs, and aqueducts; our highways, streets, and sewers. It is the civil engineer who rescues our swamp lands from ruinous overflow and deadly miasma; who liberates our lowlands from the grasp of ocean; who by extensive irrigation converts a desert into a garden.

It is the mechanical engineer who converts the energy stored in a lump of coal, a gallon of petroleum, or a waterfall into moving machinery, the work of which multiplies the comforts and luxuries of life, while it lightens the burdens and shortens the hours of labor of the toiling millions.

It is the electrical engineer who reconverts the solar energy stored ages ago in the coal measures of the earth, or stored year by year on the uplands and slopes of the mountain torrents, back into light and currents of electric energy.

It is the mining engineer who develops and utilizes the boundless stores of wealth and energy hidden below the earth's surface. It is inconceivable that the Architect and Ruler of the physical universe buried beneath the surface of planet or sun such infinite mines of precious and useful ores, and all for naught. The thought is unworthy—no modern man entertains it for one moment. The earth is ours and the fullness thereof, from surface to center. This is your peculiar field of activity.

How little we really know of the sphere we live on! We have not even explored its entire surface. Doubtless we shall soon have authentic maps of the Arctic zones, but when shall we know what is under out feet just ten miles down? At present it is all speculation.

A few years ago I went down a mile in a Lake Superior copper mine. It was exceedingly interesting, but it provoked the question, What is there another mile down, and then another? What rocks? What ores? What temperature? I own an acre of land in St. Louis, and my property extends down four thousand miles. Can any assessor tell what I am worth?

The problems of engineering are not all solved. In fact the work of solution has but just begun. There is plenty for you to do as you step from the lecture room and laboratory to take up the responsibilities of educated, well-trained men. The best thought of today is that the wealth of nature is not to be squandered and wasted. Our natural resources are to be conserved. We are to be not only husbandmen, but thrifty husbandmen.

What boundless and attractive fields of human activity are here! Every branch of engineering calls up the names of men who have served humanity and helped build the civilization of today. When I mention canals, you will think of the early exploits of the English Brindley, and the Suez Canal built by the great Frenchman deLesseps; you will recall the German ship-canal across Holstein, and you will stop only with the Panama Canal, the most stupendous feat ever undertaken. If I speak of redeeming lowlands, you think of parts of Holland recovered or soon to be recovered by fine engineering from the Zuyder Zee. The mention of dams brings up the great dams in Egypt to regulate the flow of the Nile, and the reservoir dams in New England and in Old England, that store up pure water for the millions. The word "Bridges" brings up a hundred names, from Telford and Robert Stephenson to James B. Eades, Sir Benjamin Baker, and George S. Morrison. And so on without limit. These and others are engineers, and these are some of the achievements which give inspiration and direction and scope to the peculiar kind of higher education to be gained in every technical institution of high grade.

Though greatly diversified in practice, all these special lines of engineering science and art require the same mastery of mathematics, the same knowledge of physics, the same graphical skill, the same familiarity with the theory and use of instruments of precision, the same readiness at chemical and mechanical analysis, and the same personal experience of the strength and elasticity of materials. Here in four years of study of these subjects, under expert direction and guidance, with opportunities for combining theories with practical tests, you have been trained to vigorous and courageous manhood; with minds so furnished and disciplined that, whatever be the calls made upon you, either in the strict lines of engineering, or in the varied responsibilities of industrial and commercial life, you will surely exhibit the incalculable value of a generous and broad education.

Permit me a few words to the Faculty and the graduating students in my audience today. This is the great harvest day of the year. Today you gather the fruit of four years' labor and expense. I will not pretend to figure out just how much each of these eager young engineers has cost. You can divide the year's gross expense by the number of diplomas granted this year and you will find approximately the worth, or rather, the cost per man. Is there any doubt about the *worth* of your product? The price of wisdom is above rubies! Solomon prayed for a "wise and understanding heart," and his prayer was granted. I feel sure that these young men have more or less consciously prayed or the same noble blessing. I hope their prayers have been or will be granted. A wise and understanding heart means more than scholarship, more than manual skill, more than technical acumen, more than wealth, more than popularity. It may include all these, it must include several of them—it must include high character, an unspotted life, a devotion to what is true in form and in essence, a consecration to service;—

> * * * "I pray thee then—
> Write me as one who *serves* his fellow men."

I wish you personal success in a very high sense, and to that end I wish to impress upon you two things. I do not mean that you should study your work, go to the bottom of every problem you have to solve. You will do that anyway, if you are made of sound material capable of intense stress and a high elastic limit. The two things I emphasize are these:

1. An inflexible determination never to endorse what you believe to be bad engineering. Let the temptation be ever so great, the bribe ever so fascinating, stand like a rock. Let the wind blow! Let the rain descend!—stand your ground! Some years ago I wrote in an album as a "Maxim for Conduct":

"In matters of sentiment, go with the stream; in matters of principle, stand like a Rock!" Carry that away with you.

2. Cultivate the graces and refinements of really good society. Acquire (unless you have it already) a perfect mastery of your mother tongue, and in your leisure hours make yourselves familiar with the masterpieces of literature and art. For ten or twelve years the late Professor John B. Johnson and I were members of a Fortnightly Club that

studied the books which were well worth studying and discussing, from Homer to James Russell Lowell. Professor Johnson felt, and I feel, that those hours were full of the greatest profit and the keenest pleasure. Your influence in the world and the pleasure of your life will depend partly upon your engineering skill, but more upon your manners, your speech, and your breadth of culture. Too often in the past the engineer has been associated in the popular mind with a smoky chimney, greasy machinery, and bad English. That was Sir Lester Deadlock's idea in Dickens' "Bleak House." Accordingly a recent writer in urging a more generous course of study for technical students, says: "It would be a sorry epitaph, that one was born a *man*, and died an engineer." Let your epitaph be: "Here lies one who was born a common man, and who died a great engineer."

One word more. You are to be not only engineers and cultivated men—you are to be citizens. As already hinted you are to serve your fellowmen. You are to combine Utility and Culture in Service.

We live in a new world, under the light of a new civilization. Our institutions are not founded upon or buttressed by human slavery, white or black; might no longer makes right; the burly robber of the Middle Ages is no longer our ideal of a good citizen. We are as certain of the Brotherhood of man as of the Fatherhood of God.

Bloody war is being relegated to the past; our ideals of heroism and manly nobility are not to be found in the prize ring or in the arena; they are to be found in the performance of the many duties of citizenship. Fellowship and not warfare should be our motto. Co-operation rather than hostile competition should be our practice. It is a glorious thing to help solve problems in such a way that every solution leads on to a higher civilization. Let us tear down the walls which separate nations one from the other; let us dismantle the forts, disband the army, and let us among ourselves lay aside warfare and adopt the methods of brotherhood. It is yours to help on the happy age when Science and

"Art shall flourish,
And knowledge shall grow to more and more,
And all men shall be brothers,
And the most useful shall be the most beautiful,
And 'Service' shall be the watchword,
The key that shall unlock the gates of Paradise."

APPOINTMENTS.

Mr. George H. Cox has been appointed Assistant-Professor of Mineralogy and Petrography to succeed Mr. G. W. Corey, resigned. Mr. Cox is a graduate of Northwestern University, and pursued graduate work in Geology at the University of Wisconsin. During the last year he has been engaged at the University of California as Instructor in Petrography and Structural Geology. Mr. Cox has had an extensive experience in Geological Field Work, having spent two seasons with the Wisconsin Geological Survey in the lead and zinc districts of that State, one season with the United States Geological survey, one season mapping iron deposits in Wyoming, one season in examining copper deposits in Montana, one season in Alaska, and during the summer of 1909 has been engaged in the work of the Illinois Geological Survey.

Mr. C. R. Forbes has been appointed Assistant-Professor of Mining. He is a graduate of the Michigan College of Mines, and was Assistant in Mechanical and Mining Engineering at that institution for one year after graduation. He has had a large experience in the Michigan copper mining district as engineer for mining companies, and has had charge of important pieces of work, including the erection of stamp-mills, hydraulic air-compressors, rock-houses, head-frames, and ore-bins. For two years Mr. Forbes was engaged in mining engineering work in Utah and Nevada.

Mr. F. W. Buerstatte has been appointed to succeed Mr. E. W. Smith as Instructor in Mechanical Drawing. Mr. Buerstatte is a graduate of the University of Wisconsin in Mechanical Engineering. For two years he was engaged with the Chicago and Northwestern Railroad in the Mechanical Department, and for two years in the Locomotive Testing Department. From 1905 to 1907 he was engaged as draftsman with the Railway Appliance Company, and the Keystone Harvester Company. Since March 1907 he has been chief draftsman for the American Well Works of Aurora, Illinois.

Mr. E. P. Barrett has been appointed Instructor in Chemistry to succeed Mr. D. P. Hynes, resigned. Mr. Barrett has been Assistant in the Department of Chemistry for two years, and has also been employed for several seasons during the summer school.

Mr. J. T. McVey has been appointed Instructor in Civil Engineering to succeed Mr. J. V. Howe, resigned. Mr. McVey is a graduate of Lehigh University in the Civil Engineering course. The first year after graduation he was employed in the maintenance corps on the Delaware, Lackawanna and Western, and the Central of Georgia railroads. During the past two years he has been engaged as Instructor in Civil Engineering at the Michigan Agricultural College.

Mr. F. E. Dennie has been appointed Instructor in Physical Training and in Civil Engineering. Mr. Dennie is a graduate of Brown University in Civil Engineering, and for four years has been actively interested in the Athletics of Brown University. He has been a member of the football and baseball teams representing that University for several years, and was rated by critics as one of the best college men in football and baseball. Mr. Dennie will have charge of all of the work in the Gymnasium, and on the Athletic Field.

Dr. L. A. Test has been appointed Assistant-Professor in Chemistry to succeed Professor R. C. Thompson, resigned. Dr. Test is a graduate of Purdue University and of the University of Chicago. He was Instructor in Chemistry at Purdue University for three and one-half years, Instructor and Chemist at Colorado Agricultural College for four years, and since 1907 has been Professor of Chemistry at Occidental College, Los Angeles.

Mr. C. W. Keniston has been appointed Assistant in the Experiment Station. He is a graduate of the School of Mines in the Class of 1909.

Mr. J. P. Walker of Great Falls, Montana, has been appointed Special Assistant in the Experiment Station. Mr. Walker attended the School of Mines some years ago. In 1900 he was employed as Chemist in the Laboratory of the American Car and Foundry Company of St. Charles, Missouri. He then took charge of an assay office at Neihart, Montana. After being employed at that place for one year he went to Great Falls, Montana, as Assistant-Chemist with the Boston and Montana Company. He has been in the service of this company for eight years, and at present is Chief Chemist in charge of the Electrolytic Plant Laboratory.

MISSOURI MINING EXPERIMENT STATION.

The Forty-fifth General Assembly of the State of Missouri, realizing the needs of the mining industry of Missouri, provided funds for establishing a Mining Experiment Station in connection with the School of Mines at Rolla. The Board of Curators has created the Missouri Mining Experiment Station as a department of the School of Mines and Metallurgy, and has organized the station on the same general plan as the Agricultural Experiment Station.

It shall be the object and the duty of the said Mining Experiment Station to conduct such original researches or to verify such experiments as relate to the properties and uses of mineral products; to investigate the engineering problems connected with the mineral industry, the economic methods of mining and the preparation of mineral products, the methods of preventing waste of the mineral resources and the methods of preventing accidents in mines, mills, and smelters; to assist in improving the conditions surrounding the labor in mines, mills, and smelters; and such other researches or experiments as bear directly upon the application of mining and of metallurgical engineering to the mineral industry of the State of Missouri.

From time to time bulletins or reports of progress shall be published by the said Mining Experiment Station, one copy of which shall be sent to each newspaper in the State of Missouri and to such individuals actually engaged in mining as may request the same and as far as the means of the Station will permit.

The Staff of the Mining Experiment Station shall consist of the Director of the School of Mines, the Professor of

Metallurgy, the Professor of Ore Dressing, the Professor of Mining, and the Professor of Chemistry.

Special investigators may be appointed to carry on research along any line approved by the Station Staff. Station Assistants shall be appointed to carry on the regular work of the Station. Research Fellows may be appointed to carry on experimental work for the Station provided the applicant for appointment is matriculated as a graduate student and is a candidate for a degree in the School of Mines.

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THE HISTORY AND THE DEVELOPMENT OF THE CYANIDE PROCESS.

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The subject is divided into the following chapters:—

I.—HISTORY.
II.—CRUSHING.
III.—ROASTING.
IV.—CLASSIFICATION.
V.—SOLUTION.
VI.—PRECIPITATION.
VII.—REFINING.

References to literature on the Cyanide Process are grouped at the end of each chapter.

I.—HISTORY.

The history of the salts of cyanogen covers about two hundred years and the solubility of gold and silver in certain of these salts has been known for approximately one hundred years.

The first cyanogen salt, of which mention is made, is Prussian blue. This compound was discovered by Dusbach (1) in 1704, but he had no idea of its composition.

About 1750 Macquer (2) found that it was ferrocyanide of potassium which combined with iron salts to form Prussian blue.

The next step was the discovery of potassium cyanide by Scheele (3) but it was not until 1815 that Gay Lussac (4) succeeded in determining the composition of the radical, cyanogen (CN). He also discovered (5) the acid, HCN.

In 1806 Hagen (6) predicted, that potassium cyanide would dissolve gold. He placed potassium cyanide in the group with chlorine, bromine, and iodine (7). The knowledge of this fact was not made use of by any one for nearly thirty-five years, when in 1840 Elkington (8) discovered that potassium cyanide aided by electricity would dissolve gold. The same year he patented (9) his discovery.

There is some question as to whom the credit is due for first putting the solution of gold in cyanide to commercial use. A Dr. Wright, of Birmingham, England, seems to have used it for electro-plating as early (10) as 1840.

While investigating the patented process of Elkington's, a Russian Prince, P. Bragration, (11) published a paper in which he stated that:

I. Gold is soluble in potassium cyanide.

II. The finer the gold, the more rapid is its solution.

III. The electric current does not aid the solution in any way.

IV. Heat is of great benefit.

V. The electric current is not necessary for the precipitation of gold on metallic surfaces.

VI. The solution of gold in potassium cyanide is hastened by the presence of air.

The next year, 1844, Elsner (12) stated that gold is soluble in potassium cyanide and that the dissolution of the metal is due to the oxygen absorbed from the air. Philip Argall states (13) that Elsner discovered the solubility of gold in potassium cyanide, but that the solution was the result of the presence of oxygen was published in 1846 (14); also that he did not give out his equation to that effect until 1866.

In 1857 Farraday (15) announced that gold leaf is one hundred times more soluble when placed on the surface of a potassium cyanide solution than when immersed in it, the work having been done the previous year.

In 1866 Wurtz (16) found that gold was soluble in dilute solutions of potassium cyanide.

The next step was the granting of a patent (United States Patent No. 61866, February 5, 1867) to Julio F. Rae (17), of Syracuse, New York, for the treatment of auriferous and argentiferous ores by potassium cyanide. His method was to crush the ore and then treat it by potassium cyanide aided by electricity and agitation, precipitating the gold by electricity. This method was never used, although it was along the lines of present practice.

In 1875, William Skey (18), of New Zealand, called attention to the fact that the use of potassium cyanide on amalgamated plates caused a loss of gold. He cautioned mill men against its excessive use.

From this date until 1880 nothing seems to have been done with the process, when a patent was issued to Clark (United States Patent No. 229586, 1880) (19) for the use of potassium cyanide in metallurgical operations. The next year (1881) a patent was issued to Faucett (United States Patent No. 234424, 1881) (20). The same year a patent was issued to J. F. Sanders (United States Patent

No. 244080, July 12, 1881) (21) for the use of potassium cyanide for the removal of the coating from gold preliminary to pan amalgamation.

The first patent of any importance was issued to Jerome W. Simpson (22) (United States Patent No. 323222, July 28, 1885) for the separation of gold and silver from their ores. His method was to grind the ore to a powder, and then treat the ore with a mixture of about the following composition:

KCN	1 pound
$(NH_4)_2CO_3$	1 ounce
NaCl	½ ounce
H_2O	16 quarts

He agitated, settled, and then put in a sheet of zinc to precipitate the metals. If silver was not present he omitted the sodium chloride. He stated that the idea of the use of zinc and potassium cyanide did not originate with him.

In 1884, A. P. Price (23) applied for and was granted a patent (English Patent No. 5125) for the precipitation of gold and silver, by zinc in a fine state of division, from cyanide solutions.

During the next two years, two caveats were filed covering the use of potassium cyanide for the extraction of gold and silver from their ores, one in the names of F. M. Endlich and N. H. Muhlenberg, in the spring of 1885 and the other in the name of Louis Janin, Jr., in 1886, but no patents were issued (24).

On October 19, 1887, McArthur and Forrest were granted their English Patent (English Patent No. 14174). Their application for a patent in the United States was dated November, 1887, but the patent was not issued until May 14, 1889 (United States Patent, No. 403302) (25). Their claim, or patent, as finally granted by the United States, was for the extraction of gold and silver from their ores by a solution of potassium cyanide which contained not over eight parts of cyanogen (CN) per thousand.

Sometime later they were granted a patent on the precipitation of gold and silver from cyanide solutions by zinc, preferably in a filiform, or threadlike, condition and on the use of caustic alkali (26) to neutralize the acid in the ores.

In 1887 the first plant was installed at the New Zealand Crown Mines, Karangahake District, by the Cassel Gold Extraction Co. They used agitation (27) for a time, giving it up in favor of percolation.

The first plant in South Africa was erected by Butters to treat the tailing from the Robinson Mine at Johannesburg. This plant was started December 23, 1890 (28). The gold production of South Africa by cyanide was less than six thousand dollars for 1890 (29). The writer understands that the first cyanide plant in the United States was erected about the year 1891 but has been unable to learn where and when it was erected. Matt W. Alderson (30) states that one of the first successful plants in the United States was the Revenue Mill in Montana.

After this date the process seems to have come into general favor and its development was very rapid. This is shown by the output of South Africa (31), which for 1890 was less than six thousand dollars, for 1891 was sixty thousand dollars, and for 1892 was three hundred thousand dollars.

The next point of interest was the introduction of crushing in a dilute solution of cyanide. This, according to Philip Argall (32), was introduced by Almarin B. Paul at the Calumet Mill, Shasta County, California, in 1891 (33).

In 1892 Gaze (34) discovered the benefits of using the halogen salts of cyanogen to aid the solution of gold.

The next year Argall claims the credit of introducing the separation of the dust and slime from the sand and the separate treatment of each (35).

According to Thomas N. Smith, (36) agitation and filter-pressing were introduced at the mill of the Attica mine which commenced operation July 23, 1893. At this date there were only five or six cyanide mills in the United States. The production of South Africa for this year by cyanide was six million dollars. Also McArthur patented the idea of adding soluble lead salts to the cyanide solution to prevent the formation of sulpho-cyanides (39). Argall (40) states that this modification was patented by McArthur and Ellis in 1896 (United States Patent No. 555463, February 25, 1896).

In 1895 Argall claims to have introduced the roasting of sulpho-telluride ores (41).

In 1896 the decantation process was introduced by J. R. Williams (42) at the Crown Reef Gold Mining Company's mill, whch began operation August 1896. In the same year Diehl (44) claims to have used a filter-press.

The estimated production of gold by the cyanide process for 1897 was (45):

United States................	190,000 fine ounces
World	1,215,000 fine ounces

At this time there were forty cynide mills in the United States (46).

The next year, 1898, J. W. Southerland (47) introduced tube-milling and filter-pressing into the Australian gold fields.

The world's production of gold by cyanide for 1900 was (48), according to G. T. Beilby:

United States	497,820 ounces bullion
Transvaal	85,000 ounces bullion
Other countries	1,243,233 ounces bullion
Total	1,826,053 ounces bullion

During 1903 Moore was granted a patent on a suction, or vacuum, filter (United States Patent No. 748088, December 23, 1903) but this filter was not a success. In 1904 a second patent was issued to him, (United States Patent No. 764486, July 5, 1904) (49).

The next year (1904) Cassel was granted a patent on a vacuum filter (United States Patent No. 773473, December 25, 1904) (50). This filter differs from the Moore in that the filter is fixed, the solutions being changed instead of the filter being moved from one tank to another.

In 1905 Ridgway (51) introduced his revolving automatic suction filter. During 1906 the consumption of potassium cyanide was ten thousand tons, of which South Africa used about one-third. (52).

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II.—CRUSHING.

The method of crushing the ore previous to its treatment by the cyanide process is important. If the ore is to be treated by percolation, machines should be chosen which will crush the ore to the requisite fineness and produce the minimum of fine material which cannot be treated by percolation. If the ore is to be ground fine and treated by some method of agitation, the production of fine material will be a benefit. If the ore must be roasted, some method of dry crushing must be used. If it is to be amalgamated, some wet method will be used.

The important item of cost must be considered carefully. Especially is this true at the present time when much attention is being given to the working of low-grade deposits and to the perfection of the mechanical details of construction.

Wet Crushing.—There is probably more ore crushed wet in stamps, than by all other methods combined. This is probably due to the fact that cyanide is used as a secondary treatment after amalgamation and it seems to be the almost universal practice to crush by stamps for amalgamation.

The most noteworthy point in connection with the crushing by stamps has been the great increase in the weight of the stamps, used in South Africa. A few years ago there were few, if any, stamps used in Africa which were over one thousand pounds in weight. In 1907, stamps weighing from sixteen hundred fifty to eighteen hundred pounds were being installed, and at the present time stamps are being considered which weigh up to twenty-five hundred or three thousand pounds. It seems rather peculiar that such heavy gravity stamps should not be replaced by some form of steam stamp, especially since there is no longer any objection to the production of fine sand and slime.

Other methods of wet crushing are used such as breakers followed by rolls and Chilian mills, or breakers followed by rolls alone.

Dry Crushing.—While wet crushing seems to lead, the output of dry crushing plants is by no means small.

Alfred James (1901) (1) states that the output of gold from dry crushing plants is very large but at that time the African mines were shut down on account of the war. It appears that dry crushing (2) is cheaper.

Dry crushing is used extensively in Australia where a large amount of the ore is a sulpho-telluride which must be roasted. This is also true of the Cripple Creek ores from below the oxidized zone which have not been weathered on dumps.

There are two general methods of dry crushing:

I. By breakers and rolls.
II. By breakers and ball-mills.

It is difficult to state which of these methods is the better. Alfred James (3) prefers the ball-mill. Philip Argall, at the Metallic Extraction Works, Florence, Colorado, used rolls.

For the fine grinding of sands for treatment by agitation or filter-pressing, the tube-mill has been adapted practically the world over. There are a few mills in Australia and a few in other parts of the world where pans are used.

Tube-mills will grind either wet or dry material and at the present time they are the most efficient machines for this class of work. When working wet, Bosqui (4) states that the best mixture is one part of sand to one part of water.

Almost every form of crushing device has been used in some plant. Some were successful, others failures. It is difficult to state whether it was the fault of the machine or of the man in charge. The engineer must decide for each plant which method of crushing should be used and must be guided to some extent by local conditions.

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III.—ROASTING.

When it was attempted to treat the unoxidized sulphotelluride ores, metallurgists found that it was necessary to roast the ore and that it should be roasted "sweet". Almost every furnace on the market has been tried. The majority of mill-men seem to prefer a form of roasting-furnace having one roasting hearth and mechanically rabbled or a revolving furnace. James (1) states that the "Argall," "Edwards," and the "Ropp" appear to be the most successful. The requirements for roasting this class of material are:

I. The heat must be applied gradually.

II. The finishing heat must be fairly high in order to break up the sulphates if possible and to drive off all the sulphur.

III. The rabbling must not be violent as the ore is usually in a fine condition and loss by dust would be great.

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IV.—CLASSIFICATION.

There are several methods of classification, the more common being by means of spitzkasten tnd spitzluten, or by cone classifiers.

During the last few years, the Dorr clasifier has come into general use and it seems to be a success.

At Hannan's Brownhill Mine (Mineral Industry, Vol. 7, page 326), the dry material is classified by air.

V.—SOLUTION.

The next step is the solution of the gold. There are three general methods of doing this:

1. **Percolation.**
2. **Agitation.**
3. **Filter-Pressing.**
4. **Other Methods.**

1. **Percolation.**—Percolation is usually done in vats. In the old plants the vats were of almost any size and shape, while in the modern plants the tanks are of great size holding from four hundred to six hundred tons or more.

In most of the modern plants the tanks are of steel, circular, and varying in size according to the capacity of the plant. Butters (1) states that about the largest tanks in the world are at the Rand Central Ore Reduction Company and are fifty feet by sixteen feet. At one time rectangular tanks were used but experience has shown that they are not as satisfactory as the round tanks. One trouble with the rectangular tanks is the difficulty of keeping the solution from cutting channels in the corners of the tank.

In the bottom of the tank is placed a filter. These filters are usually of cloth resting on a lattice work of wood or on boards full of auger holes, supported on stringers. The filter used at the Homestake Mill is ten-ounce duck over cocoa matting (2). At the Metallic Extraction Company's Plant at Florence, Colorado, the filter was ten-ounce duck over cane matting on a board frame (3). Sand is sometimes used as a filter and where used is usually covered with burlap or canvas to protect it.

The vats are filled in various ways. If the ore is crushed dry, the more common way of filling is by hand. The ore is loaded into cars which are trammed to the tanks and dumped. When the tank is filled it is leveled off. If the ore is crushed wet it is, after the removal of the slime, run into the tanks, usually some form of mechanical distributor being used.

When the ore contains a large amount of free acid, or soluble acid salts, the usual practice is to wash the ore either with water or with an alkaline solution, caustic soda or lime being the alkalies ordinarily employed.

If the ore contains only a small amount of these salts, or acids, enough lime (CaO) is usually added to the ore to neutralize the acid salts and acids.

Lime is not the only alkali used. Some ores have a tendency to "set" (like cement) in the tanks, in which case lime makes this condition worse. Sodium and potassium hydroxide are used but they are usually more expensive than lime, and, if the ore contains soluble sulphides, they form the alkali sulphides. This can be remedied by the addition of soluble lead salts which form lead sulphide (PbS) which is not acted on by the cyanide solution to any extent.

The strength of the solution must be determined for each case. The extremes of general practice seem to be between 0.01 of one per cent or 0.2 pounds of potassium cyanide per ton (4) and 0.5 of one per cent or ten pounds per ton (5), although weaker and stronger solutions are probably used.

It is aimed to keep the protective alkalinity high enough so that there will always be at least one-half pound of free alkali per ton of solution.

The rate of percolation is determined from a commercial stand-point. It is a question as to whether it is better to percolate more slowly and treat more of the fine material, or to maintain a higher rate and treat more slime by agitation. It is seldom that the rate of percolation is less than one inch per hour, but this rate is used (6). The amount of solution used per ton of ore and the time of leaching must be determined by experiment. In South Africa it is the practice to use 1.3 to 1.5 tons of solution per ton of ore and leach for from four to seven days (7). At another plant the ore is leached sixteen days (8). After the gold has been dissolved and the solution drained off, the residue is washed, sometimes with dilute cyanide solution followed by water, or with successive water washes until the solution coming from the vat is too low-grade to treat. The washing is then discontinued and the tailing is discharged.

The tailing may be discharged in several ways, some of which are as follows:

I. It may be sluiced out through doors in the side and in the bottom of the vat.

II. It may be shoveled into cars or to belt conveyors through bottom doors.

III. It may be discharged by means of some of the mechanical appliances designed for this purpose, such as the Blaisdell excavator.

2. **Agitation.**—Today agitation is superseding the old method of percolation. The oldest patents granted used agitation but this was discarded in favor of percolation. This change of practice was probably due to the lack of the proper machinery. As time went on vast amounts of valuable slime accumulated, which could not be treated by percolation. Engineers turned their attention to methods of handling this material. Argall (9) claims the credit for first separating the fines and slimes from the sand and treating them separately. Williams (10) introduced the decantation process into South Africa while to Southerland (11) probably belongs the credit of introducing slime treatment into Australia.

The material to be treated by agitation should be in a fine condition. If not fine it settles rapidly and packs. This requires violent agitation and is a needless waste of power. If the material is coarse the solution of the gold is slow and it is not practical from a financial stand-point to agitate one charge several days.

The methods of agitation are numerous. In South Africa the methods which seem to be most in use are two in number. One allows the pulp to flow from the bottom of a tank into a centrifugal pump which discharges the material into the top of the same tank, or the top of another tank.

The other method employs a series of radial arms attached to a central shaft and this is rotated by bevel gears. These arms travel just fast enough to keep the mass in motion. In Australia pans were used but were found to be too small and the agitator having radial arms now seems to be the favorite. The United States does not seem to have any standard practice. There are many other forms of agitators, some of which are as follows:

The Brown (12) consists of a tank from twelve to fifteen feet in diameter by from forty to fifty-five feet deep, having a conical bottom. In the center of this tank is a pipe having a diameter of about one-twelfth that of the tank. Into the bottom of this pipe compressed air is introduced which causes the pulp to flow upwards through the pipe, aerating as well as agitating the pulp.

The Hendrix (13) is about the same as the Brown except that instead of air a screw propeller is used to raise the pulp, At the top of the central tube is a plate to carry the pulp to the edge of the tank. This plate is often amalgamated, and is the cathode for precipitating by electricity.

Another form employs compressed air. It has arms, arranged like a revolving sprinkler, placed close to the bottom of the vat. Through these arms compressed air is forced.

The solution used in agitation, as a general rule, is not as strong as that used for percolation. Lime is the general alkali used. There are two reasons for this: first, that it furnishes the necessary alkali; and second, that it helps to coagulate the slime, giving a greater settling rate.

There are three general methods of separating the solution from the slime.

A. Decantation.
B. Filter-Pressing.
C. Filtering with a Vacuum Filter.

Another method used is to carry out all the work in the filter-press.

A. THE DECANTATION PROCESS.—This method is used principally in Africa where it originated. There the principal methods of agitation are either circulating the pulp by means of a centrifugal pump, from the bottom of one tank, through the pump, to the top of the same tank or of another tank, or by mechanical gitation, the agitator with radial arms being preferred. At some properties a combination of these methods is used.

After the gold is in solution, which takes from four to eight hours, the agitation is stopped and the pulp, to which lime has been added at the time of crushing, is allowed to settle. The clear solution is siphoned off, more solution added to the remaining pulp, which is then agitated just enough to mix thoroughly, settled, and the clear solution again siphoned. This dilution, agitation, settling, and siphoning is continued until the pulp is low enough in value to throw away. It is then discharged. When discharged the pulp is usually about fifty per cent moisture. One objection to this method is the large amount of solution which must be handled. This necessitates an expensive plant.

B. FILTER-PRESSING.—There are two methods of pressing used:

a. Single Pressing.
b. Double Pressing.

In the single pressing method the slime is dewatered in settlers and then run to agitators, usually of the radial arm, mechanically driven type and agitated with solution until the gold is dissolved. The slime is then run to filter-presses, washed in the press and discharged.

In the double pressing method the slime is dewatered by filter-presses before going to the agitators. This enables them to treat a pulp in the agitator containing less water than is possible by the single pressing method. After agitation it is pressed, washed, and discharged as in single pressing. The cake or tailing when discharged contains fifteen to twenty-five per cent moisture and they use (14) about one ton of water per ton of ore.

In Australia the dewatering of the slime is accomplished by the use of the filter-press, the decantation process never having met with much favor. This is probably due to two causes: first: The scarcity of water, second: The high value of the ore treated would take too much dilution, in other words require the handling of too much solution before the tailing could be discharged.

C. VACUUM FILTER.—Vacuum filtering seems to be the favorite method in the United States at the present time. The solution of the gold in the slime is carried out by various schemes of agitation. The solution is then withdrawn, the tailing washed and discharged by means of a vacuum filter such as the Moore, Butters, Ridgway, and others.

3. **Filter-Pressing.**—Another method of treating slime is to carry out the entire operation in the filter-press. This method is used at the Homestake Slime-Plant where the Merrill Press is used. It presents the advantages of using pressure during the solution of the gold and the use of a minimum quantity of solution and wash water.

4. **Other Methods of Solution.**—BROMO-CYANIDE.—Bromo-Cyanide was used for years in Australia for the treatment of sulpho-telluride ores without roasting. It has also been used at Deloro, Can., at the Telluride Mill, Colorado City, Colo., and at some other places. It depended on the use of bromo-cyanide mixed with potassium cyanide to dissolve the

gold. The method was finally replaced at most places by roasting and fine grinding. It is, however, still used at a few mills. The worst feature of the process is the cost of the bromine or the bromo-cyanide used.

Cyanide of Mercury.—Dr. Keith, (15) claims to have invented the use of cyanide of mercury.

He used a solution of 0.05 per cent potassium cyanide and 0.025 per cent cyanide of mercury. The gold and mercury were precipitated on amalgamated copper plates by electricity.

Schilz Process (16).—The Schilz process was tried in South Africa and depended on the use of a strong solution of potassium cyanide with barium peroxide, leaching for a long time.

Berger Cyanide Process (17).—The Berger process depended on the use of centrifugal pumps to aerate the solution, thereby supplying the necessary oxygen to effect the solution of the gold. This method was used at the Dorcas Mill, Florence, Colorado.

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VI.—PRECIPITATION.

The general methods of precipitation in use at the present time are:

1. **Precipitation on filiform zinc.**
2. **Precipitation by electricity, or the Siemens-Halske process.**
3. **Precipitation by zinc dust.**
4. **Other methods of precipitation.**

1. **Precipitation on Filiform Zinc.**—This method of precipitation on filiform zinc is the oldest of the methods in use at the present time. It is also used to a greater extent than all other methods combined. The precipitation of the gold and silver is accomplished by passing the gold-bearing solution slowly through a box, or some other form of container, filled with zinc shavings or thread. The precipitation is a replacement, the zinc replacing the gold in solution.

The precipitation box, extractor, or zinc-box is usually built of wood or enameled iron and varies in size, depending upon the amount of solution to be precipitated. It is considered best to have a separate box for each class of solution which is to be precipitated; thus, a mill in which the solutions used are a strong solution, a weak solution, and wash water, should have three boxes. The boxes are usually from fourteen to twenty feet long, from two to four feet wide, and from two to three feet deep. Each box is divided into from five to ten compartments. These compartments should be arranged so that the depth is greater than any other dimension (1). In order to prevent the clogging of the box by the precipitated slime and the material which is carried there mechanically, baffle-boards are placed at the head of each compartment. The baffles force the solution to the bottom of the box and it then rises through the zinc. In each compartment and about four inches from the bottom is placed a screen tray of about one-eighth-inch mesh (2) on which the zinc rests. Usually the first and last compartments are used as settlers, the others being packed with freshly-cut zinc. The shavings should be packed in the box evenly, the corners being well-filled. Care should be taken that there are no bunches of zinc which will not allow the solution to pass and that the entire mass is loose enough to insure a free passage of the solution. The zinc is cut or turned on a lathe, the turnings being about 1/1260 of an inch thick and 1/32 of an inch wide (3). One pound of turnings has about fifteen hundred thirty square feet of surface (4). When the turnings are packed in the box they weigh about six and one-quarter pounds per cubic foot (5).

The length of time that the solution should be in contact with the zinc is dependent on the strength and purity of the solution. James (6) states that for weak, foul solutions the time of contact should be from one and one-half to two hours. Stronger solutions would not take as long a time of contact.

The rate of flow through the box is dependent on the time of contact necessary to precipitate the gold and silver. The rate varies from about one-half ton solution per cubic foot of zinc per twenty-four hours for weak solutions, to about two tons per cubic foot of zinc per twenty-four hours for strong solution. General practice seems to be about one ton per cubic foot of zinc per twenty-four hours for ordinary strong solutions and about one-half this rate for weak solutions.

It has been found that pure zinc is not as good as ordinary commercial zinc which usually contains lead, but it should not contain over 1.5 per cent lead (8).

In the early days of the process, trouble was experienced in precipitating the gold from weak solutions. This led to the introduction of the zinc-lead couple and the zinc-mercury couple. In the former, the zinc shavings are placed in a ten per cent solution of lead-acetate for a few minutes. This was patented by McArthur and Ellis (9) (United States Patent No. 592153, October 19, 1897) and was introduced at the Crown Deep Slime Plant by T. L. Carter and W. K. Betty (10).

The zinc-mercury couple was patented by Caldecott (11) (United States Patent No. 620100, February 28, 1899).

The amount of zinc consumed is approximately one-half to one pound of zinc per ton of ore treated. James (12) states that it is about one-quarter pound per ton of ore treated.

The following statements show the consumption of zinc: Bodie, California (13) 0.1839 pounds of zinc per ton of ore. Metallic Extraction Company, Florence, Colorado, (14) 5.31 ounces troy of zinc precipitated one ounce of gold, and one-tenth ounce of silver. Horseshoe Mill, Dakota, (15), one pound of zinc per ton of ore. Dakota Mill, Dakota (16) 0.58 pounds of zinc per ton of ore.

As fast as the zinc in the box is consumed it must be replaced. This is usually done every twenty-four hours or oftener if necessary. The fresh zinc is always added to the last or lowest compartment, the old zinc being moved up to the compartment above it. When it is desired to "clean up" the box the solution is turned off and water is run through the box until most of the cyanide is washed out. Then the zinc is stirred and taken out. The short zinc on the screen may be sent to the refinery and with it may be sent part of the coated zinc thread. The amount of zinc taken from the box will depend upon how close it is desired to "clean up". Sometimes it is better to lose zinc in refining than to leave the gold-coated zinc in the box and pay interest on the money invested. The slime which has settled is discharged through valves or gates in the bottom of the box. The box is then repacked, the old zinc being used and fresh added to make up for that removed.

2. **Precipitation by electricity or the Siemens-Halske Process.**—This process was first used commercially in 1894 at the Worchester Mill in the Transvaal. The chief advantage claimed for the electrolytic precipitation is its ability to pre-

cipitate the gold for exceedingly dilute solutions (17). It has been and is extensively used in South Africa, but at the present time it seems to be on the decline. This decline, no doubt, is due to the fact that it is now possible to precipitate weak solutions by zinc. It has never been used to any extent in America. In 1904 there were two plants in the United States and one in Mexico (18).

The process as carried on for years used vats, anodes, and cathodes of various sizes. In 1897 standard size vats were being used (19). The vats intended for treatment of the solution from percolation plants were thirty-two feet long by five feet wide and five feet deep and contained one hundred fifty-six anodes. Those intended for use in slime plants were thirtw-two feet long by ten feet wide and five feet deep and contained two hundred eighty-eight anodes spaced four and one-half inches apart. The anodes were of iron and were usually about three-sixteenths of an inch thick. The cathodes were of sheet lead weighing about three ounces per square foot. The current density employed was about 0.06 ampere per square foot of anode surface. The voltage was just sufficient to overcome the resistance and varied from two to five or six volts, depending upon conditions of the solution and the construction of the vat.

The following is a description (20) of a vat in use at the Croesus Works:

"Boxes thirty feet long by four feet, seven and one-half inches wide, by nine feet deep. Each box contains, one hundred twenty-one iron anodes four and one-half feet wide, three feet high by three-sixteenths of an inch thick, and one hundred twenty cathode frames each holding four sheets of lead four feet by two feet (seventy-six hundred eighty square feet of cathode surface figuring both sides.) Each box will precipitate fifty tons of solution from one-tenth ounce to a trace per twenty-four hours. The solution travels one hundred twenty by eight feet or nine hundred sixty feet in fourteen and one-half hours, or one foot per minute".

3. **Precipitation by Zinc Dust.**—The zinc dust method of precipitation has been used for years but has not met with great success. Its use has been confined to a few of the larger plants. The method as used consists of spraying the zinc dust or "fume" into the solution to be precipitated and agitating for a short time to insure a complete mixture. The solution is then passed through a filter-press to collect the precipitate.

4. **Other Methods of Precipitation.**—There are several other methods of precipitation which are not in general use, the most important of which is the precipitation by charcoal. In this, the JOHNSON PROCESS (21), the solution is passed slowly through crushed charcoal. There are several points in its favor, some of which are as follows: The fineness of the bullion is high and the extraction is high regardless of the strength of the solution (22). The principal objections to it are: A large bulk of charcoal is required. It requires forty filters, each holding five hundred sixty pounds of charcoal to precipitate four hundred tons of solution per week (23). The consumption of cyanide is large. There is danger of loss by dusting when burning the charcoal after precipitation (24). This method has not met with general usage but it has been used at several mills.

THE PELATAN-CLERICI process was patented December 17, 1895, (United States Patent No. 551684) (25) and has been used in a few places in the United States but it was a failure. The process consisted of agitating the ore with cyanide. The bottom of the agitator was an amalgamated copper plate which served as a cathode, the arms of the agitator (26) being the anode.

The MALLOY PROCESS was the precipitation by means of sodium or potassium amalgam, which was formed electrolytically in the precipitator as fast as required.

THE BETTLE PROCESS (28) precipitated the gold and silver by electricity. It is practically the same as the Siemens-

Halske except that Bettle used a cathode of zinc instead of lead.

THE MOLDENHAUER PROCESS (29) uses aluminum in place of zinc.

THE ANDRELAI METHOD (30) is the same as the Siemens-Halske except that he uses an anode of lead coated with lead peroxide.

SHERARD COWPER-COLES (31) uses a cathode of aluminum instead of lead as in the Siemens-Halske.

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VII.—REFINING OF THE PRECIPITATE.

The refining of the precipitate obtained in the cyanide process, especially that obtained by precipitation by zinc, is necessarily a troublesome operation. It is due to these facts: First, the precipitate is in a fine condition and there is danger of loss from dust; second, that the precipitate is high in zinc and in all smelting operations a high percentage of zinc causes trouble; third, the high value of the material makes a high percentage extraction necessary. The most important methods of refining the precipitate are (1):

1. **Direct Fusion with Fluxes.**
2. **Roasting and Fusion.**
3. **Treatment with Acid and Fusion of the Residue.**
4. **Smelting with Lead Salts and Cupellation of the Resultant Lead Bullion (Tavener).**
5. **Volatilization of the Zinc and Fusion of the Residue.**

1. **Direct Fusion with Fluxes.**—This is the oldest method of refining the precipitate and at the present time it has been discarded. The objections to it were the difficulty of eliminating the zinc and other impurities from the bullion and of obtaining a clean, liquid slag; and the excessive cost of fluxing the large volume of precipitate which must be handled. The method of procedure was to dry the washed precipitate and then charge it, with suitable fluxes, into graphite crucibles. Nitre was generally used to oxidize the zinc.

2. **Roasting and Fusion.**—Roasting followed by fusion was used extensively in South Africa (2). This method is to roast the precipitate at a dull red heat until the zinc is oxidized. The roasting is usually carried on in a cast-iron muffle, the precipitate being placed in shallow iron pans. Care must be used in this operation to prevent loss of gold by dusting. If the heat is too high the volatilizing zinc will carry with it gold. After the roasting is complete the pre-

cipitate is cooled, broken up, and charged with the proper fluxes into crucibles and melted.

3. **Treatment with Acid and Fusion of the Residue.**— This method of treatment is being used in most of the plants in the United States. The object of treating with acid is to remove the zinc before fusion, thereby saving the large quantity of flux required to slag the zinc. The objections to this method are the cost of the extra equipment required to treat the precipitate by acid, the loss due to solution of the precious metals, and the danger from the formation of the extremely poisonous gas, hydrocyanic acid (HCN). If arsenic is present in the ore treated, Arsine (AsH_3) is formed, a gas, as dangerous as the hydrocyanic acid. The method presents the advantage of effectively removing the greater portion of the zinc and other impurities present, which are soluble in the acid used. The removal of the zinc and other soluble salts makes it possible to treat a much higher grade precipitate in the furnace and saves the cost of the fluxes required to slag the zinc.

The method used is as follows: The precipitate as it comes from the box is dewatered to a greater or less extent and then charged to the acid or "cutting down" tank. This tank should always be mechanically agitated and have a close-fitting hood with a very strong draft. This is to protect the men attending to this work from the hydrocyanic acid, arsine, and other poisonous gases which are given off during the acid treatment. The acid, usually sulphuric, on account of its low cost, is added and the mixture agitated until the solution of the zinc is completed. Heat may be used to aid the solution of the zinc. The material is then filtered, the residue dried, then charged to the crucible with fluxes, and melted. This is usually done in a graphite crucible having a capacity of from two to three gallons. This fusion is poured and when cold the resultant button is broken off. The buttons thus obtained are either sent to the mint directly or are remelted and cast into bars. The slag may be crushed and concentrated, or may be amalgamated to recover the gold. The concentrate, which is mostly gold-shot, is saved and mixed with the next melt. Accumulations of slag, if of any value, are sold to the smelter.

4. Smelting with Lead Salts and Cupellation of the Resultant Lead Bullion (Tavener).—This method, or some modification of it, is used in South Africa and at some of the larger plants elsewhere. It seems to be the best method in use, if there be a large amount of precipitate to be refined, but for use in small plants, it is not favored. The method is to mix the dry or partially dry precipitate with suitable fluxes. In one case, the mixture to be smelted was as follows:

Slime	30	per cent.
Litharge	32.5	per cent, ten per cent of which is saved for a cover.
Coal	4.1	per cent.
Iron	16.0	per cent in the form of tin plate scrap.
Assay Slag	16.0	per cent.
Silica	8.3	per cent in the form of clean quartz.
	95.0	per cent.

This is then charged to a reverberatory furnace with the lead from the last by-product smelt and fused. As the slag forms it is run off and saved. When the entire charge is melted and liquid the balance of the slag is run off and the lead is withdrawn and cast. The resultant lead is then cupelled. The impure slag is smelted in a small blast-furnace, the lead bullion obtained from this being the lead added to the reverberatory furnace at the time of smelting the precipitate. The litharge obtained from the cupellation of the lead bullion is saved and used with the next charge. A method somewhat similar to this is in use at the Homestake Mill.

5. **Volatilization of the Zinc and Fusion of the Residue.**—This method consists of volatilizing the zinc and smelting the residue. Rose (4) states that Sulman and Picard at Deloro found a great loss of gold due to its being mechanically carried off by the zinc.

REFERENCES.

1. Metallurgy of Gold, T. K. Rose, Page 298, Fifth Edition, 1906.

2. Mineral Industry, Vol. 4, Page 329, W. R. Ingalls.

3. Mineral Industry, Vol. 16, Page 525, Chas, H, Fulton.

4. Metallurgy of gold, T. K. Rose, Page 304.

DANIEL C. JACKLING, B. S., 1892, Met. Eng., 1903
General Manager Utah Copper Company
Vice-President Ray Consolidated Copper Company

The Jackling Field.*

For a number of years the northern portion of the School of Mines campus, which portion comprises about eight acres, has been set aside as an athletic field. Considerable grading was necessary in order to fill depressions and make the surface regular enough for such games as football and baseball. However, as the ground sloped rapidly from north to south, the tract of land was not well adapted to these games. The total difference in elevation was twenty-eight feet, and there was a fall of ten feet from the north to the south end of the football field.

Year after year the grading of the field was discussed, but owing to lack of funds the work was delayed. In 1905, through the energetic interest of the late Professor W. W. Garrett, a running-track was graded on the south side of the field. This track was a great improvement, but was expensive to maintain on account of the wash from the baseball field. Test-pits showed that bed-rock was at a depth of from three to five feet near the north end of the baseball diamond and about six feet deep at the south end of the diamond. Pits were dug at various points over the field and showed that on the southern half of the field grading could be carried to a depth of eight feet without striking rock in place. An average section showed three feet of clay, one foot of hardpan, one foot of clay, and three feet of sandstone boulders and clay.

The Athletic Committee recommended a field to accommodate football, baseball, tennis, field sports, and a 440-yard running-track. It was found that it would be impracticable

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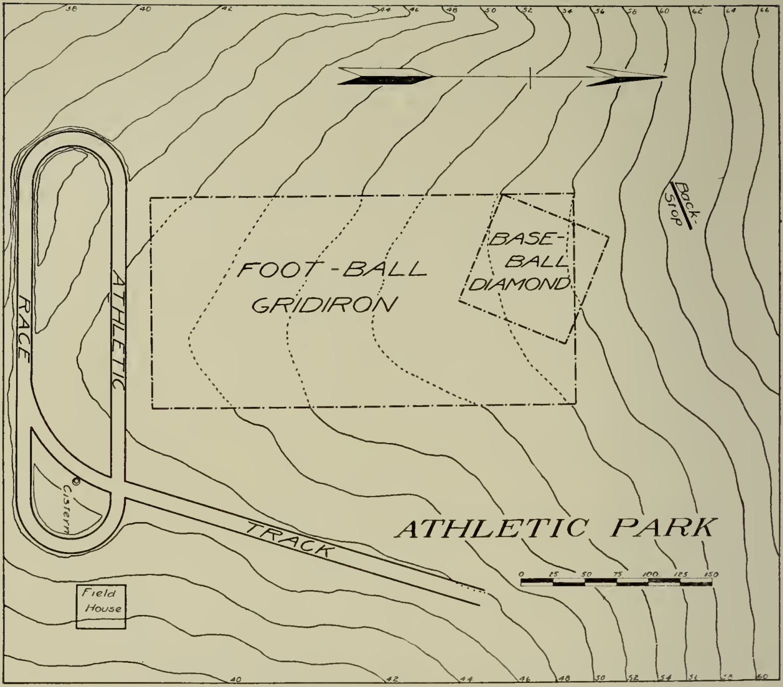
*School of Mines and Metallurgy, Rolla, Missouri.

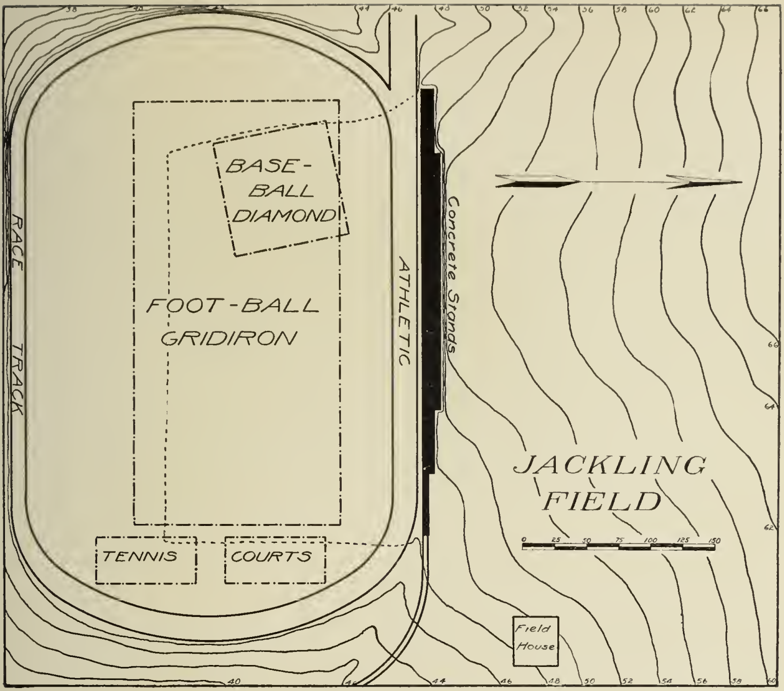


Map of Athletic Park

to complete such a field at a reasonable cost, unless the new field should be located on the southern half of the old field with the football field extending east and west.

Estimates showed that by assuming a base eighteen inches above the grade of the old 220-yard track, a suitable field could be secured by removing approximately six thousand cubic yards of clay, boulders, and hardpan. By this plan the graded field was to be a rectangle 325 by 530 feet with the north line 325 feet north of the south fence of the field. The maximum cut of seven feet was on the north side and the maximum fill of nine feet in the southwest corner. The field slopes toward the south so that there is natural drainage.

Plans for this grading were presented to Daniel C. Jackling, a graduate of the School of Mines in the class of 1892.



Map of Jackling Field

Mr. Jackling agreed to furnish funds for the work, and his gift was accepted by the Executive Committee of the School of Mines. The contract for grading was let July 12, 1909, and the work began July 16.

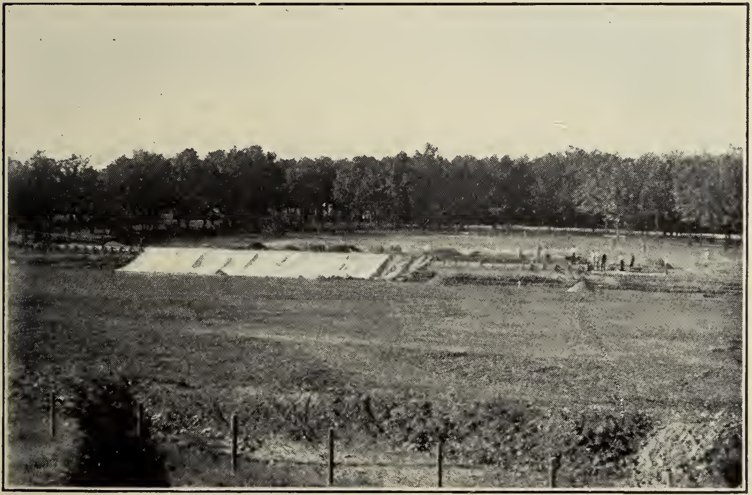
As the depth of cut on the north side of the field averaged over four feet, it was evident that the embankment would have to be terraced or held by a retaining wall of some kind. Various methods were considered, but finally it was decided to erect a concrete "bleacher" which would also serve as a retaining wall.

In order that this bleacher might be most serviceable it was built into the embankment and was planned to extend the full length of the field. Additional grading was necessary because

Looking south from bleacher showing location of field with regard to buildings

Looking north on west end of field, showing old baseball diamond on the right

Fill on southwest corner, showing character of material excavated



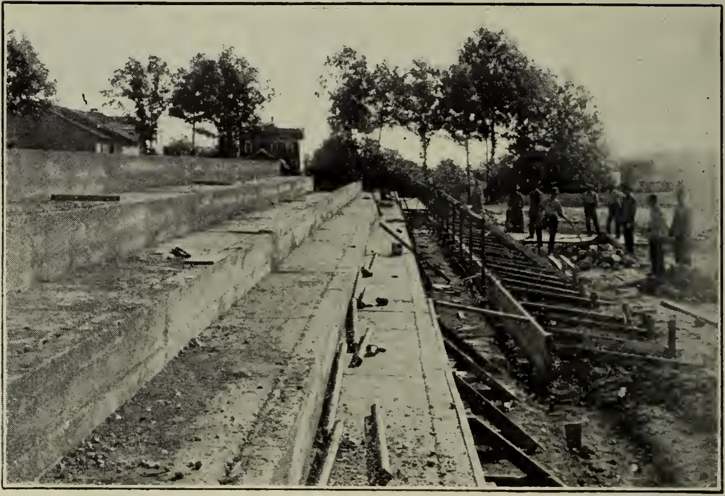
Looking north from Mechanical Hall, showing conditions and methods when building bleacher

Reinforced concrete roller

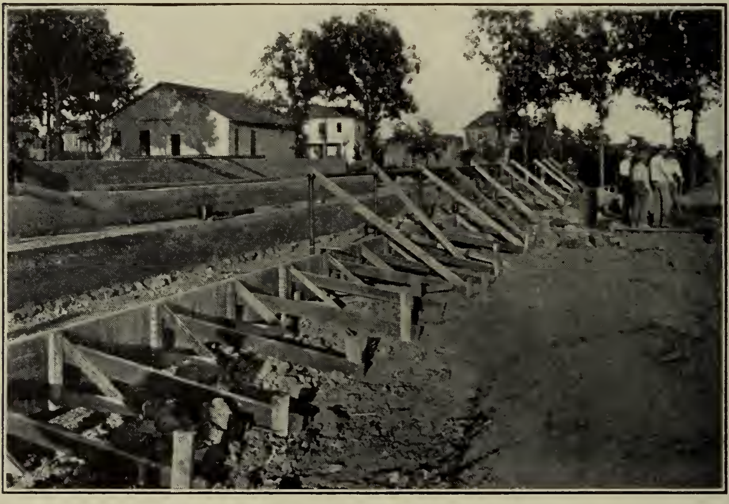
Reinforced concrete roller

Concrete bleacher construction showing forms for first step

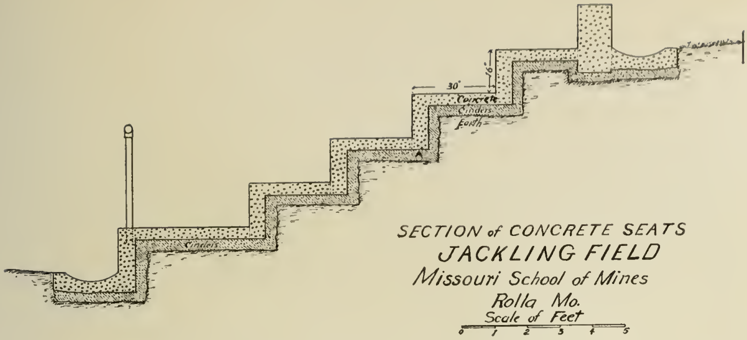
Concrete bleacher construction showing forms for second step



Concrete bleacher construction showing stakes driven to grade to support railing and forms



Concrete bleacher construction showing bracing for forms and railing



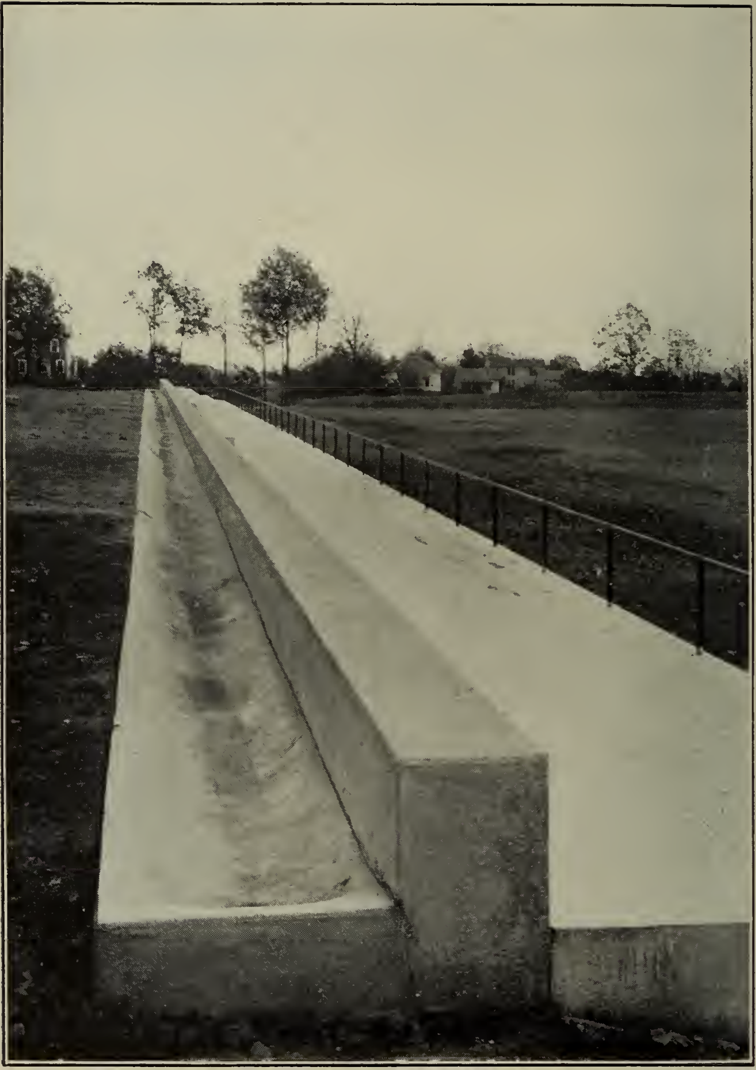
of the erection of the bleacher, and this work was not begun until the grading of the field was completed.

The bleacher proper is three hundred feet long, the risers being sixteen inches high. For a distance of fifty feet from each end, the bleacher is four risers high, and for the remaining central portion of two hundred feet there are six risers. The bottom step is four feet wide to provide a passage along the front of the bleacher. The top step is one foot wide; the intermediate steps are uniformly thirty inches in width.

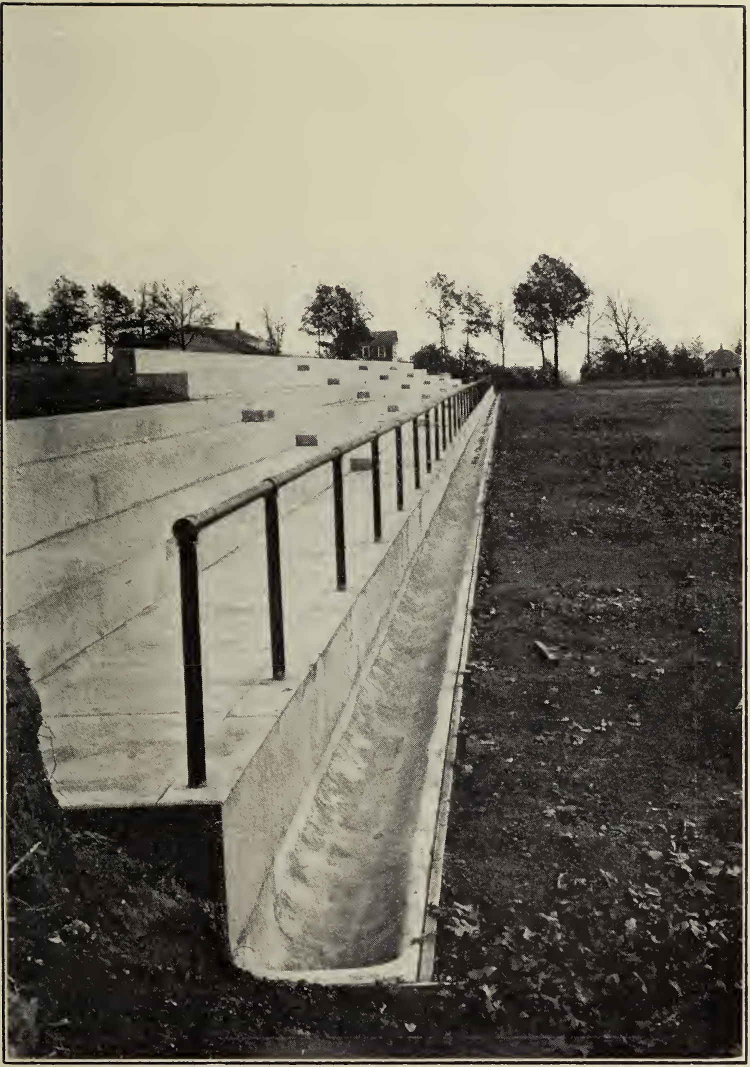
A railing of two-inch iron pipe, supported every eight feet by a two-inch pipe set fifteen inches into the concrete, rises three feet above the concrete and extends along the front of the stand from end to end.

The engineering work connected with the grading of the field, and the design and construction of the bleacher were in charge of the Faculty Committee on Buildings and Grounds, consisting of Professors Harris and McRae. The surveying for the bleacher was done by Mr. A. Park of the class of 1910. The grading was done by contract by Mr. J. Madigan of Rolla. The bleacher was erected under the supervision of Mr. R. R. Dickerson, Superintendent of Buildings and Grounds.

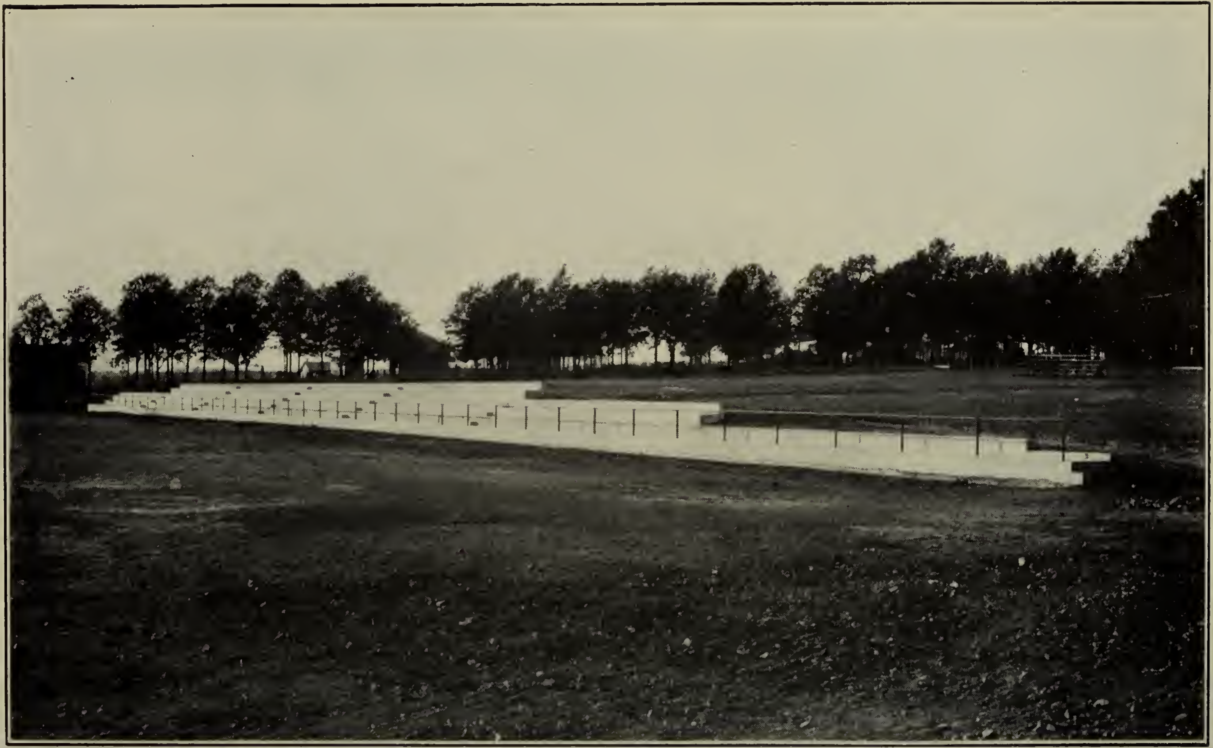
At a mass meeting held September 15, 1909, the students of the School of Mines decided to name the new athletic field in honor of the loyal alumnus who made it a reality, and by unanimous vote it is now "The Jackling Field."



View of concrete bleacher showing gutter on north side

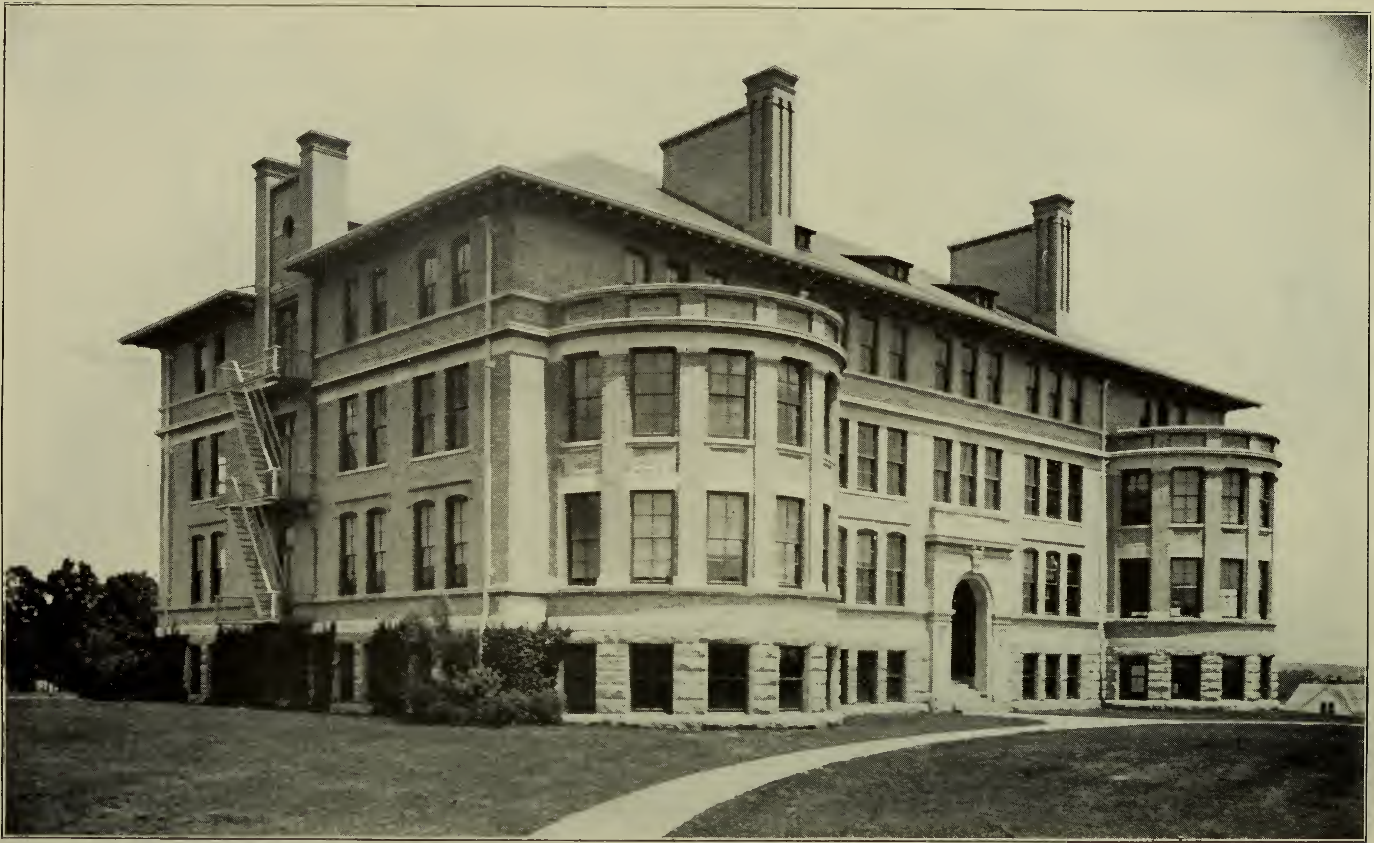


View of concrete bleacher showing gutter on south side



View of bleacher from southeast

View of The Jackling Field from Mechanical Hall



NORWOOD HALL

SCHOOL OF MINES AND METALLURGY

UNIVERSITY OF MISSOURI

THIRTY-NINTH ANNUAL CATALOGUE

Rolla, Missouri

1910

1910

JANUARY.

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CALENDAR.

1910.

March 14, Monday	Third Term Begins.
June 1, Wednesday	Annual Commencement.
June 6, Monday	Summer School Begins.
July 16, Saturday	Summer School Ends.
September 3 and 5, Saturday and Monday	Entrance Examinations. Registration for First Term.
September 6, Tuesday	First Term Class Work Begins.
December 22, Thursday at 4 p. m.	Christmas Recess Begins.

1911.

January 2, Monday	Registration for Second Term.
January 3, Tuesday	Second Term Class Work Begins.
February 22, Wednesday	Holiday.
March 10, Friday	Second Term Ends.
March 11, Saturday	Registration for Third Term.
March 13, Monday	Third Term Class Work Begins.
May 26, Friday	Annual Commencement.

BOARD OF CURATORS.

S. L. Baysinger	Rolla, Mo.
B. H. Bonfoey	Unionville, Mo.
P. E. Burton	Joplin, Mo.
D. R. Francis	St. Louis, Mo.
J. V. C. Karnes	Kansas City, Mo.
J. C. Parrish	Vandalia, Mo.
C. B. Rollins	Columbia, Mo.
T. J. Wornall	Liberty, Mo.
C. E. Yeater	Sedalia, Mo.

OFFICERS OF THE BOARD.

J. V. C. Karnes	President.
D. R. Francis	Vice-President.
J. G. Babb	Secretary.
R. B. Price	Treasurer.

EXECUTIVE COMMITTEE of the SCHOOL OF MINES AND METALLURGY.

S. L. Baysinger	Rolla.
P. E. Burton	Joplin.
T. J. Wornall	Liberty.

OFFICERS OF THE COMMITTEE.

P. E. Burton	Chairman.
Edw. Kahlbaum	Secretary.
C. M. Knapp	Treasurer.

Director of the School,

LEWIS E. YOUNG.

Secretary of the Faculty,

JOHN B. SCOTT.

Registrar,

EDW. KAHLBAUM.

Librarian,

IDA STEVENS GARRETT.

Superintendent of Buildings and Grounds,

ROBERT R. DICKERSON.

FACULTY.

ALBERT ROSS HILL, A. B., Ph. D., LL.D.... *President of the University.*

A. B., Dalhousie University, 1892; Ph. D., Cornell University, 1895; LL. D., University of South Carolina, 1905; Dalhousie University, 1908; Westminster College, 1909.

LEWIS EMANUEL YOUNG, E. M.................... *Director.*

B. S. in Mining Engineering, Pennsylvania State College, 1900; E. M., Iowa State College, 1904.

GEORGE REINALD DEAN, C. E...... *Professor of Mathematics.*

C. E., School of Mines, 1890; B. S. in Mathematics and Physics, School of Mines, 1891.

AUSTIN LEE MCRAE, S. D............. *Professor of Physics.*

B. S., University of Georgia, 1881; S. D., Harvard University, 1886.

VICTOR HUGO GOTTSCHALK, M. S..... *Professor of Chemistry.*

B. S. in Chemistry and Metallurgy, School of Mines, 1898; M. S., School of Mines, 1900.

ELMO GOLIGHTLY HARRIS, C. E........ *Professor of Civil Engineering.*

C. E., University of Virgina, 1882.

DURWARD COPELAND, S. B.......... *Professor of Metallurgy.*

S. B., Massachusetts Institute of Technology, 1903.

LEON STACY GRISWOLD, A. B.......... *Professor of Geology.*

A. B., Harvard University, 1889.

JOSEPH HENRY BOWEN *Assistant Professor of Shop Work and Drawing.*

Graduate, Miller School, Va.

LEON ELLIS GARRETT, B. S........ *Assistant Professor of Mathematics.*

B. S. in General Science, School of Mines, 1901.

FACULTY—Continued.

GUY HENRY COX, B. S., M. A. . . . . . *Assistant Professor of Mineralogy and Petrography.*

B. S. in General Science, Northwestern University, 1905; M. A., University of Wisconsin, 1908.

CARROLL RALPH FORBES, E. M. . . . . . *Assistant Professor of Mining.*

B. S., Michigan College of Mines, 1902; E. M., Michigan College of Mines, 1903.

LOUIS AGASSIZ TEST, Ph. D. . . . . *Assistant Professor of Chemistry.*

B. M. E., Purdue University, 1894; A. C., Purdue University, 1896; Ph. D., University of Chicago, 1907.

PAUL JULIUS WILKINS, B. S. . . . . . . *Instructor in Modern Languages.*

B. S., Michigan Agricultural and Mechanical College, 1869.

JOHN BENNETT SCOTT, B. S. . . . . *Instructor in English and Secretary.*

B. S. in General Science, School of Mines, 1907.

BOYD DUDLEY, JR., B. S. . . . . *Instructor in Metallurgy and Ore Dressing.*

B. S. in General Science, School of Mines, 1908.

HORACE THARP MANN, M. S. . . . . *Instructor in Metallurgy.*

B. S. in Mining Engineering, School of Mines, 1908; M. S. in General Science, School of Mines, 1909.

J. TERRENCE MCVEY, C. E. . . . *Instructor in Civil Engineering.*

C. E., Lehigh University, 1906.

FRANK EDWARD DENNIE, B. S. . . . . . *Instructor in Physical Training.*

B. S. in Civil Engineering, Brown University, 1909.

FACULTY—Continued.

FREDERICK WILLIAM BUERSTATTE, B. S..... B. S. in Mechanical Engineering, University of Wisconsin, 1901.	*Instructor in Drawing.*
*EDWARD PHILLIP BARRETT, B. S..... B. S. in General Science, School of Mines, 1909.	*Instructor in Chemistry.*
JOHN PERRY WALKER, JR............	*Assistant in Chemistry.*
DAVID LAWTON FORRESTER.....	*Student Assistant in Drawing.*
FRED EDWARD RIEDE.........	*Student Assistant in Chemistry.*
WILLIAM GROVER BRANHAM....	*Student Assistant in Physics.*
VACHEL HARRY MCNUTT...	*Student Assistant in Mineralogy.*
HARMON EDWARD MINOR.....	*Student Assistant in Surveying.*
JOHN DEE HARLAN.......	*Student Assistant in Ore Dressing.*
ROBERT BRUCE MITCHELL...	*Student Assistant in Shop Work.*
CAIRY C. CONOVER...........	*Student Assistant in Drawing.*

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*Resigned January 15, 1910.

FACULTY COMMITTEES.

Admission.

PROFESSORS DEAN, WILKINS, AND GRISWOLD.

Athletics.

PROFESSORS BOWEN, MCRAE, TEST, AND COX.

Buildings, Plant and Grounds.

PROFESSORS MCRAE AND HARRIS.

Degrees.

PROFESSORS MCRAE, SCOTT, AND DEAN.

Examinations and Schedule.

PROFESSORS GRISWOLD, BOWEN, AND GARRETT.

Graduate Courses.

PROFESSORS GOTTSCHALK AND COPELAND.

Theses.

PROFESSORS HARRIS, COPELAND, GRISWOLD, AND FORBES.

Undergraduate Courses.

PROFESSORS DEAN, MCRAE, GRISWOLD, AND GOTTSCHALK.

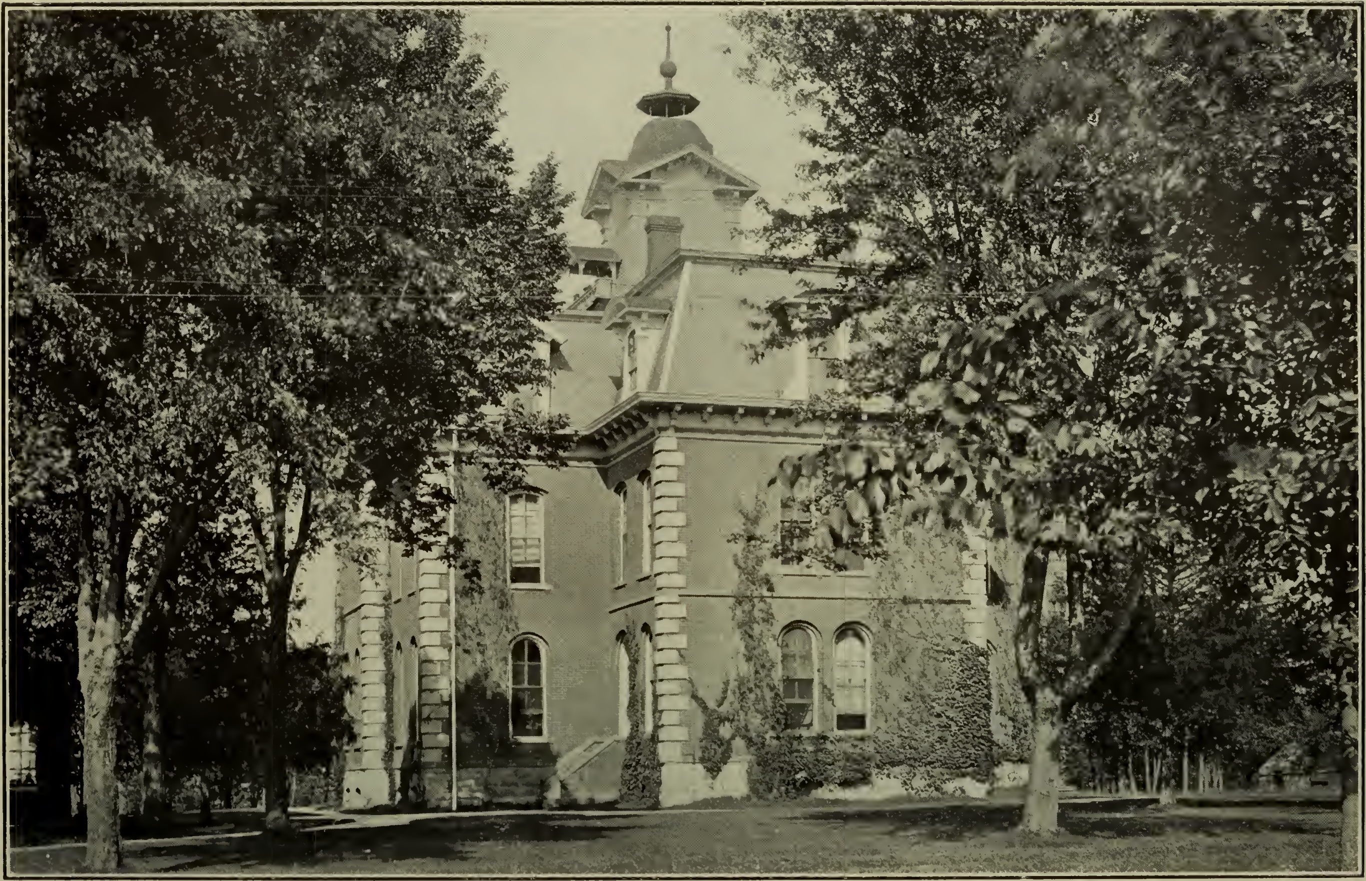
HISTORY OF THE SCHOOL.

In 1870 the General Assembly of Missouri, in accepting the donation of land for educational purposes made by the General Government through an Act of Congress, approved July 2, 1862, established an Agricultural and Mechanical College and a School of Mines and Metallurgy. The design of these institutions is set forth in the following language:

"**Objects of These Colleges.**—The leading objects of said colleges shall be to teach such branches as are related to agriculture and mining." (Session Acts, 1909, H. B. 870, Section 38.)

The School of Mines and Metallurgy was located at Rolla, Phelps County. Here, in November, 1871, the school was formally opened. The statutes fix the status of the school as one of the Colleges of the State University. Its affairs are under the immediate supervision of an Executive Committee, consisting of three members of the University Board of Curators, selected by that body. The need of general culture as a foundation and accompaniment of specifically technical training, led to the establishment, in 1885, of an Academic Course in compliance with the following Act of the General Assembly:

"**Academic Course of Study, etc.**—That the obligation of the State to the general government, assumed by the acceptance of the land grant of July 2nd, 1862, may be more fully discharged, and in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life, the board of curators of the University of the State of Missouri shall prescribe and adopt a liberal academic course of study to be taught in the School of Mines and Metallurgy located at Rolla, in addition to the courses now taught in said school, and may confer the degree of bachelor of science upon all students who shall complete said course in said school to the satisfaction of the faculty thereof." (Session Acts, 1909, H. B. 870, Section 38a.)



ROLLA BUILDING

FINANCES.

The proceeds from the sale of the public lands granted by the General Government amount to about $350,000, which is invested in State certificates of indebtedness bearing 5 per cent interest. The School of Mines receives one-fourth of the yearly income thus accruing.

By an Act of Congress, approved August 30, 1890, commonly known as the "Morrill Bill," the General Government donated to each State and Territory maintaining a college or colleges in accordance with the act of July 2, 1862, $25,000 a year. After deducting one-sixteenth of this fund for the Lincoln Institute, Missouri gives one-fourth of the remainder to the School of Mines.

In 1891, the Government returned to the various States the sums collected from their citizens by the imposition during the Civil War of a "direct tax." The amount thus refunded to Missouri was $646,958.23, and the Thirty-sixth General Assembly of the State won the gratitude of the friends of higher education by establishing this as a permanent endowment for the State University at Columbia, and the School of Mines and Metallurgy at Rolla. One-fifth of the income from this endowment, amounting to $6,469.58 per annum, is received by the School of Mines.

The Fortieth General Assembly of the State passed an act providing for a tax on collateral inheritances for the benefit of the State University, and the Forty-first General Assembly has provided that one-fifth of the funds derived from this tax shall be appropriated for the benefit of the School of Mines.

ENDOWMENT.

The State endowment of the School of Mines is set forth in the following extracts from the Statutes of Missouri:

"The proceeds of the sale of lands donated to the State of Missouri by the United States for the support of the College of Agriculture and Mechanic Arts and the School of Mines and Metallurgy, by act of Congress, approved July 2, 1863, represented by state certificates of indebtedness, of the following amounts and dates:

July 2, 1883	$242,000.00
November 1, 1883	5,000.00
January 29, 1884	5,000.00
April 19, 1884	35,000.00
April 2, 1885	5,000.00
February 25, 1886	5,000.00
January 1, 1888	5,000.00
December 15, 1888	5,000.00
May 15, 1889	5,000.00
July 1, 1891	5,000.00
May 15, 1893	5,000.00
July 1, 1895	22,881.19
April 9, 1895	5,000.00
Representing a total of	$349,881.19

Now issued or any certificates which may hereafter be issued under any general or special act of the General Assembly; one-fourth of the interest of these funds shall be paid to the Treasurer of the School of Mines and Metallurgy, at Rolla, for the maintenance of said institution."

"The proceeds of sales of lands donated to the School of Mines and Metallurgy, at Rolla, represented by the State certificate of indebtedness of $2,000, dated April 15, 1893, issued under act March 31, 1883, interest on which shall be applied to the maintenance of the School of Mines and Metallurgy, at Rolla."

"The State certificate of indebtedness of $3,000, issued under act of April 1, 1895 (pages 278 and 281, Laws 1895), dated April 1, 1896, four-fifths of the interest to be applied to the maintenance of the State University, at Columbia, and one-fifth to the School of Mines and Metallurgy, at Rolla, and also any other certificates which may hereafter be issued and held in trust for this fund under any general or special act of the General Assembly." (R. S. 1899, Sec. 10522.)

"The State certificate of indebtedness of $646,958.23, derived from 'direct tax' received from the United States, dated April 1, 1891, issued under act of March 26, 1891, four-fifths of the interest to be applied for the maintenance of the State University, at Columbia, and one-fifth for the School of Mines and Metallurgy, at Rolla." (R. S. 1899, Sec. 10522.)

"All sums collected under the provisions of an Act of Congress, approved August 30, 1890, commonly known as the 'Morrill Bill,' shall be paid as follows: One-sixteenth thereof for the benefit of the Lincoln Institute and one-fourth of the remainder to the Treasurer of the School of Mines, at Rolla, Missouri." (R. S. 1899, Sec. 10533.)

Collateral Inheritance Tax.—"The moneys received by the State Treasurer under the provisions of this article shall be deposited in the State Treasury to the credit of the fund now existing in the State Treasury, and known as the 'State Seminary Moneys,' for the maintenance, support and better equipment of the buildings, apparatus, books, instruction, etc., of the University of the State of Missouri, to an amount not exceeding in any one year the equivalent of one-tenth of one mill for every dollar of the assessed valuation of taxable property of the State for the said year; **Provided,** that one-fifth of all such moneys so received shall be devoted to the use of the School of Mines and Metallurgy, a department of the said University." (Session Acts, 1901, Section 302.)

LOCATION.

The School of Mines is located at Rolla, the county seat of Phelps County, on the St. Louis and San Francisco Railroad, approximately half-way between St. Louis and Springfield.

Rolla is on the crest of the Ozark uplift, at an elevation of eleven hundred forty feet above the sea level, and has an agreeable and notably healthful climate. Its position on a great transcontinental railway system makes it readily accessible.

The school is within easy reach of the important mining districts of the State, which offer splendid facilities for the study of mining geology, mining methods, ore dressing, and mining machinery. Numerous recent improvements, due to the systematic study of Missouri ore deposits, methods of ore treatment, and the extensive development of low-grade lead and zinc ores, have given the school advantages for the application of the theories of geology, mining, and ore dressing to practice.

The smelting industry of the State is very important and every courtesy is extended to the professors and students of the school during their visits to these metallurgical plants. The methods of mining coal and clay can be readily studied in Missouri and the adjoining fields. Numerous clay-working and cement plants in St. Louis and the vicinity offer good opportunity for the study of these important industries. In and about St. Louis are also various chemical plants which are visited from time to time.

CAMPUS AND ATHLETIC FIELD.

The grounds of the School of Mines are situated in the highest part of the City of Rolla, and are over twenty-seven acres in extent. The campus contains beautiful lawns, groves of native oak, and many shade trees.

The Jackling Field has a good baseball diamond, a football gridiron, tennis courts, and a 440-yard running-track. On the athletic field there is a suitable building providing shower-baths and a dressing-room for the various athletic teams.

BUILDINGS.

Rolla Building.

This building was originally built by the City of Rolla as a High School building, but was sold to the State in 1871, and for many years was the principal building of the School of Mines and Metallurgy. It is a brick structure, ninety feet by sixty feet, four stories high, including a working basement. It contains the library, laboratories, drafting rooms, offices, and geological collections of the State Geological Survey, recitation rooms for mathematics and modern languages, toilet, shower baths, and locker rooms.

Chemical Hall.

The main portion of this building was erected in 1885 and two wings were added in 1902. The main building is two stories high and one hundred two feet in length by fifty-five feet in width. Each wing is fifty-five feet by sixty feet and one story high. This entire building, including a large basement, is used for chemistry.

Mining Building and Power Plant.

This building, erected in 1895, is a tile-roof, press-brick structure, and consists of two distinct portions, one containing offices, a class-room, and laboratories—the other comprising a large mill-room and mining laboratory, an engine-room, and a boiler-room. Suitable offices are provided in this building for the professor of mining engineering and for the superintendent of buildings and grounds.

Mechanical Hall.

This two-story brick building, erected in 1901, is one hundred fifty feet by sixty feet and was specially designed for mechanical work. The second floor includes a demonstration lecture room, a shop for bench-work in wood, and a temporary gymnasium. The first floor contains a lathe room for wood-turning, a forge room, a metal-working room, and a stock and tool room.

Each floor is provided with a lavatory and lockers, and an office for the instructor.

Norwood Hall.

The corner stone of this building was laid November 23, 1902, and the building was first used in 1903. It contains adequate quarters for the demonstration offices, and provides lecture and recitation rooms for physics, geology, mineralogy, civil engineering, English, mathematics; also drawing rooms and laboratories for physics, geology, mineralogy, and civil engineering. The school library is located on the first floor of Norwood Hall.

Ore Dressing Building.

This is a three-story gray press-brick building with a basement and two large one-story wings. Two stories and the west wing have been in use since January, 1908, and the east wing was erected in 1909. The building provides quarters for metallurgy and ore dressing.

Director's Residence.

This is a two-story brick and frame building, erected in 1889 and used for a number of years as a student club-house and dormitory.

Athletic Building.

A one-story frame building, thirty-seven by thirty-four feet, formerly used as a wood shop, is now used by the athletic teams and provides dressing rooms, lavatory, and store room for athletic supplies.

Carpenter Shop.

The general repair work of the school and construction of laboratory equipment is carried on in a frame building, ninety feet by twenty-two feet. This building is located west of Mechanical Hall and includes a store room for lumber.

LIBRARY READING ROOM

LIBRARY.

The Library contains nine thousand carefully selected volumes and several thousand pamphlets and bulletins. Good collections of works on engineering, mathematics, chemistry, physics, mining, metallurgy, ore dressing, geology, and mineralogy afford to students an opportunity to pursue an extended course of reading in connection with their class-work. The Library also contains the standard works in English and American poetry, fiction, biography, and history. It is well provided with encyclopedias and works for general reference. All of the important technical periodicals and reports are received regularly, together with general magazines which are of interest to engineers and scientists.

Current and recent technical literature plays such an important part in present-day education that an elaborate card index of technical literature has been provided and is maintained up-to-date. More than 40,000 important articles in transactions of societies, reports, bulletins, and periodicals have been recorded and classified.

The Library is the depository for the maps, drawings, photographs, and lantern slides. A splendid series of several thousand photographs of Missouri mines, mills, and smelters is on file and indexed so that it is easily accessible. Photographs have been secured, from most of the important mining camps, of the work, and the student may supplement the daily lectures by reference to these selected illustrations.

The valuable collection of nearly three thousand maps and drawings is indexed and is used to supplement work in the class room and in the drafting room.

The Library is open from 9 a. m. until noon, from 1 p. m. to 5 p. m., and from 7 p. m. to 9 p. m., daily except Sunday.

ADMISSION.

Under the statutes persons of either sex, sixteen years of age or over, whether residents of Missouri or not, may be admitted upon evidence of sufficient preparation. Students should have a good liberal education, its elements at least, before beginning technical study. The average age of members of the present Freshman class at entrance was about eighteen years. Specific requirements have been fixed by considerations of the express design of the school—"to promote the education of the industrial classes" in certain branches of engineering—and of the educational opportunities of its intended beneficiaries. The requirements for admission to the Freshman class are as follows:

The applicant must file with the Director a satisfactory certificate of good moral standing.

Admission by Examination.—Applicants for admission, not having diplomas from approved schools, are required to pass, without conditions, examinations in fifteen units, a unit being the equivalent of a year's work in one subject, as given in an approved high school.

Of these fifteen units the following are required: Three units in English, one and one-half units in Algebra, one unit in Plane Geometry, and one-half unit in Solid Geometry. The remaining nine units may be selected from the following list:

Subject.	Maximum.	Minimum.
English	4	3
Algebra	1½	1½
Plane Geometry	1	1
Solid Geometry	½	½
Plane Trigonometry	½	½
History	4	1
Latin	4	1
Greek	3	1
German	3	1
French	3	1
Spanish	3	1
Physics	2	1
Chemistry	2	1
General Biology	2	1
Zoology	2	1
Botany	2	1
Drawing	1	1
Shopwork	1	1
Civil Government	½	½
Physiology	1	1
Physiography	1	1

Mathematics.—The four units which may be offered in mathematics are as follows:

Algebra. One and one-half units. Elementary algebra, including the elementary operations, solution of simple and simultaneous linear equations, factoring, radicals, exponents, quadratic equations, equations containing radicals, imaginaries, simultaneous quadratics, higher equations solved as quadratics, relations of roots and co-efficients of quadratics and higher numerical equations, solution of higher equations by factoring, Horner's method of approximation, binomial theorem for positive integral exponent, ratio and proportion, and logarithms.

While the study of these particular subjects is recommended, it is not expected that the student shall be able to pass an examination on each and every one of them. He must produce evidence, however, of having studied algebra for one and one-half years under a good teacher in an accredited high school.

Plane Geometry. One unit. The work in Plane Geometry must cover a full year in any good text. It is recommended that considerable attention be paid to the applications of the algebra to geometry, and of goemetry to algebra and arithmetic.

Solid Geometry. One-half unit. A full half-year's work is required in Solid Geometry. The same recommendations apply here as in Plane Geometry, with the additional requirement that the student be drilled in arithmetical work in computing areas and volumes.

Trigonometry. One-half unit. It is to be understood at the outset that this work will not be accepted for advanced standing. This branch of mathematics is of such great importance to the practical engineer that the whole subject must be reviewed, and the student led to a point of view which it is impossible to attain in a high school course.

English.—The four units that may be offered in English include grammar, composition and rhetoric, and literature.

The candidate will be required to show a reasonable proficiency in the principles of English grammar, including sentence-analysis. He will be required to show the ability to express himself coherently and correctly, with a fair mastery of the forms of writing, spelling and punctuation, sentence and paragraph structure. He will be examined on the literature listed below, and, if he desires four units, will be required to show also a knowledge of the history of English literature.

The classics prescribed are as follows:

I. For Study and Practice. Shakespeare's *Macbeth;* Milton's *Lycidas, Comus, L'Allegro* and *Il Penseroso;* Burke's *Speech on Conciliation* or Washington's *Farewell Address,* and Webster's *First Bunker Hill Oration;* Macaulay's *Life of Johnson* or Carlyle's *Essay on Burns.*

II. For Reading. Group 1 (two to be selected): Shakespeare's *As You Like It; Henry V.; Julius Caesar; The Merchant of Venice; Twelfth Night.*

Group 2 (one to be selected): Bacon's *Essays;* Bunyan's *The Pilgrim's Progress,* Part I.; Addison's *Sir Roger de Coverley;* Franklin's *Autobiography.*

Group 3 (one to be selected): Chaucer's *Prologue;* Spenser's *Faerie Queene* (Selections); Pope's *The Rape of the Lock;* Goldsmith's *The Deserted Village;* Palgrave's *Golden Treasury* (First Series), Books II. and III., with especial attention to Dryden, Collins, Gray, Cowper, and Burns.

Group 4 (two to be selected): Goldsmith's *The Vicar of Wakefield;* Scott's *Ivanhoe;* Scott's *Quentin Durward;* Hawthorne's *House of the Seven Gables;* Thackeray's *Henry Esmond;* Mrs. Gaskell's *Cranford;* Dickens' *A Tale of Two Cities;* George Eliot's *Silas Marner;* Blackmore's *Lorna Doone.*

Group 5 (two to be selected): Irving's *Sketch Book* (Selections); Lamb's *Essays of Elia;* DeQuincey's *Joan of Arc* and *The English Mail Coach;* Carlyle's *Heroes and Hero Worship;* Emerson's *Essays* (Selected); Ruskin's *Sesame and Lilies.*

Group 6 (two to be selected): Coleridge's *The Ancient Mariner;* Scott's *The Lady of the Lake;* Byron's *Mazeppa* and *The Prisoner of Chillon;* Palgrave's *Golden Treasury* (First

Series), Book IV., with especial attention to Wordsworth, Keats, and Shelley; Macaulay's *Lays of Ancient Rome;* Poe's *Poems;* Lowell's *The Vision of Sir Launfal;* Arnold's *Sohrab* and *Rustum;* Longfellow's *The Courtship of Miles Standish;* Tennyson's *Lancelot and Elaine, The Passing of Arthur, Gareth and Lynette;* Browning's *Cavalier Tunes, The Lost Leader, How They Brought the Good News from Ghent to Aix, Evelyn Hope, Home Thoughts from Abroad, Home Thoughts from the Sea, Incident of the French Camp, The Boy and the Angel, One Word More, Herve Riel, Pheidippides.*

History.—Four units may be offered in history; one each in Ancient History, Medieval and Modern History, English History, and American History.

Civil Government. One-half unit may be offered in Civil Government. This is the equivalent of one-half year's work in the fourth year of a high school and the applicant should have a knowledge of the chief organs of local, state, and national government, and a knowledge of the historical development of the government.

Physiography.—A student may offer one unit in physiography. A description of this unit will be sent on request.

Physics.—The two units that may be offered in physics are as follows:

1. A year's work, five periods per week, of which at least two must be double periods in individual laboratory work. At least thirty-five exercises, selected from a list of sixty or more, equivalent to those recommended by the National Educational Association, must be completed.

2. A continuation of the laboratory for another year, or a year's work in a more advanced text together with the laboratory work.

Laboratory note-books must be presented by those who are required to take the entrance examination.

Drawing.—One unit may be offered in drawing and is as follows:

A year's thorough work in freehand drawing, or in mechanical drawing, or in a combination of the two. This unit is the equivalent of five laboratory periods per week throughout the year. Drawings must be presented by students desiring credit in this subject for entrance. This unit will be accepted for admission but not for advanced standing.

Freehand. The ability to draw and paint natural growths (leaves, flowers); to give correct proportions, perspective, and light and shade in drawing from geometric solids, vases, etc.; to paint with water colors from simple objects (fruit vases); to make designs suitable for book covers and school programs, in black and white and in color.

Mechanical. Use of instruments and plain lettering; simple geometrical problems; plain freehand lettering and dimensioning; plans, elevations, and cross-sections; development of the *idea of plan, elevation* and *section* from geometrical solids; drawing accurately to scale plans, elevations, and sections from pupil's own measurements; and dimensioned freehand sketches of simple machine parts; plan and elevation of some building measured by pupils. The explanation and practice of isometric and cabinet views as applied especially in joinery.

Combination. The ability to draw, as outlined under the Freehand Course, without the painting; the use of the instruments, plain lettering, the drawing of simple plans and elevations as outlined under the Mechanical Course.

Manual Training.—One unit may be offered in manual training and the candidate must give satisfactory evidence of having completed a year's work of five periods per week of at least one and one-half hours each. This work will not be accepted for advanced standing.

Latin.—The four units that may be offered in Latin are as follows:

1. Collar and Daniell's First Latin Book, or the equivalent.

2. Three books of Caesar's Gallic War with composition based thereon in Moulton and Collar's Preparatory Latin Composition or in Daniell's New Latin Composition. For one book of the Gallic War the equivalent in time of Viri Romae, Nepos, or Eutropius may be offered.

3. Two additional books of the Gallic War and four Orations of Cicero with compositions based thereon in the books mentioned above.

4. Ovid's Metamorphoses (2,000 lines) and four books of Virgil's Aeneid, with prosody.

Greek.—The three units that may be offered in Greek are as follows:

1. Ball's Elements of Greek, or White's First Greek Book.

2. Four books of Xenophon's Anabasis, Pearson's Greek Prose Composition, or its equivalent, Goodwin's Greek Grammar.

3. Ten orations of Lysias and the first four books of Homer's Odyssey, or an equivalent amount of other Greek authors. Bridgman's Parallel Exercises based on Lysias.

German, French, Spanish.—Three units may be offered in German, French, or Spanish. A description of the units will be sent on request.

Chemistry.—The two units that may be offered in chemistry are as follows:

1. A year's work in chemistry, five periods per week, of which at least two must comprise laboratory work.

2. A second year's work in the subject, five periods per week, of which at least two must be laboratory work.

Note-books showing work done must be presented by those who are required to take the entrance examinations.

These courses will be accepted for admission but not for advanced standing.

Admission on Diploma.—Applicants may be admitted upon certificate from a college, high school, or preparatory school when the Faculty is satisfied that the work certified to covers the requirements of the School of Mines and Metallurgy.

Each applicant must file with his diploma a statement, on a School of Mines and Metallurgy blank, from his superintendent or principal, showing that the applicant has to his credit fifteen units.

Following is a list of schools whose courses have been approved by the University, and whose diplomas will admit to the Freshman class without examination.

ACCREDITED SCHOOLS.

Albany High School
Alton (Ill.) High School
Appleton City Academy
Aurora High School
Bartlesville (Okla.) High School
Belton High School
Bethany High School
Bevier High School
Blees Military Academy, Macon
Bonne Terre High School
Boonville High School
Bowling Green High School
Braymer High School
Breckinridge High School
Brookfield High School
Butler High School
Cairo (Ill.) High School
California High School
Cameron High School
Campbell High School
Carleton College
Carrollton High School
Carterville High School
Carthage High School
Caruthersville High School
Centralia High School
Charleston High School
Christian College
Chillicothe High School
Clinton High School
Columbia High School
Covington (Ind.) High School
Culver (Ind.) High School
Davenport (Ia.) High School
De Soto High School
Dexter High School
Doniphan High School
East St. Louis (Ill.) High School
Elmwood Seminary
Enid (Okla.) High School
Excelsior Springs High School
Fayette High School
Ferguson High School
Flat River High School

VIEW ON THE CAMPUS

Fort Scott (Kan.) High School
Fort Smith (Ark.) High School
Fredericktown High School
Fulton High School
Gallatin High School
Grant City High School
Greenfield High School
Greenville (Miss.) High School
Guthrie (Okla.) High School
Hamilton High School
Hannibal High School
Hardin College, Mexico
Harrisonville High School
Higginsville High School
Holden High School
Hopkins High School
Hot Springs (Ark.) High School
Huntsville High School
Iberia Academy
Independence High School
Jackson High School
Jackson Military Academy
Jefferson City High School
Joplin High School
Kahoka High School
Kansas City Central High School
Kansas City Manual Training School
Kemper Military Academy, Boonville
Kennett High School
Keokuk (Ia.) High School
Kewanee (Ill.) High School
Kidder Institute
King City High School
Kirksville High School
Kirkwood High School
Knobnoster High School
Lamar High School
Lancaster High School
Leavenworth (Kan.) High School
Lebanon High School
Lee's Summit High School
Lexington High School
Liberty High School
Lockwood High School
Logan County High School (Guthrie, Okla.)
Louisiana High School
Macon High School
Maitland High School
Malden High School
Marionville Collegiate Institute
Marshall High School
Maryville High School
Memphis High School
Mexico High School
Missouri Wesleyan College
Moberly High School
Monett High School
Montgomery City High School
Mound City High School
Mt. Vernon High School
Muskogee (Okla.) High School
Neosho High School
Nevada High School
New London High School
Norborne High School
Odessa High School
Oklahoma City (Okla.) High School
Okmulgee (Okla.) High School
Oregon High School
Palmyra High School
Paola (Kan.) High School
Paris High School
Pierce City High School
Pine Bluff (Ark.) High School
Plattsburg High School
Pleasant Hill High School
Poplar Bluff High School
Princeton High School
Quincy (Ill.) High School
Rich Hill High School
Richmond High School
Ridgeway High School
Rock Port High School
Rolla High School

St. Charles High School
St. Charles Military Academy
St. Joseph High School
St. Louis Central High School
St. Louis McKinley High School
St. Louis Manual Training School
St. Louis Yeatman High School
Salisbury High School
Savannah High School
Sedalia High School
Shelbina High School
Shelbyville High School
Sikeston High School
Slater High School
Smith Academy
Springfield High School
Steelville High School
Sweet Springs High School
Synodical College (Fulton)
Tipton High School
Trenton High School
Troy High School
Tulsa (Okla.) High School
Unionville High School
University Military Academy (Mobile, Ala.)
Van Buren (Ark.) High School
Vandalia High School
Walther College, St. Louis
Warrensburg High School
Washington High School
Webb City High School
Webster Groves High School
Wellston Station High School, St. Louis
Wentworth Military Academy, Lexington
West Plains High School
Western Military Academy
Westport High School
William Woods College, Fulton
Windsor High School

Advanced Standing.—Candidates may be admitted to advanced standing either upon examination in the subjects of the previous year or years, or upon certificate from another institution, of work accomplished, which is, in the estimation of the Faculty, equivalent to that completed here by the class into which entrance is sought. Applicants for advanced standing should communicate with the Director as early as possible, and all claims for advanced standing, in order to receive recognition, must be made by the student within one term after entrance.

Special Students.—Special students will be admitted without passing the regular examinations required for entrance, under the following conditions: 1. They must be at least twenty-one years of age. 2. They must show good reasons for not taking a regular course. 3. They must pass such examinations or other tests as shall demonstrate fitness to pursue profitably all the subjects selected by them. 4. They shall not be candidates for a degree. 5. Special students are expected to do particularly good work in the subjects which they choose. If, at any period of the session, their work becomes unsatisfactory, their connection with the school will be severed. When the work is chiefly of a laboratory nature they will be required to take at the same time as much classroom work as the Faculty may designate for each particular case.

Since there are many persons who would profit by the opportunities for education offered at the school, but who are unable, through lack of time or preliminary training, to undertake the work of the regular course, the Faculty has made the above provision. In this way it hopes to broaden the usefulness of the school, and to enable it to fulfill its purpose in as liberal a manner as possible.

UNDERGRADUATE COURSES.

It is the object of the instruction at this institution, first, to lay a broad and solid foundation by acquaintance with principles and theory, and to supplement this, wherever possible, by the discipline of practical application in the laboratory and field. Lectures and recitations are arranged for the morning hours, leaving the afternoon for laboratory and field work. The practical work is designed to illustrate and impress principles, to familiarize the student with the use of instruments with which he is to be concerned in the work of his profession, and to afford an opportunity for original investigation. What is taught orally in the lecture room is applied and illustrated in the laboratory.

The School of Mines offers four regular courses leading to degrees.

I. Mining Engineering.

II. Metallurgy.

III. Civil Engineering.

IV. General Science.

The first is a general course in Mining Engineering having in view all of the operations in connection with mining, from the prospecting to the delivery of the finished product on the market. Instead of the regular work outlined for the Senior year in the Mining Engineering course, a student who has satisfactorily completed the work of the first three years of this course may elect one of the three optional courses outlined on pages 38, 39 and 40. These options are in Mining Geology, Mining Machinery, and Ore Dressing. They are planned for men who desire to specialize in the particular subjects mentioned and all lead to the degree of Bachelor of Science in Mining Engineering.

The second course contemplates especially processes in metallurgy subsequent to the delivery of the ore above ground. It fits a man for positions in connection with concentrating plants and smelters and various branches of industrial chemistry.

The third is a course in engineering as applied especially to railways, highways, and municipal works.

The fourth is largely elective and provides for a liberal education in General Science.

The engineering courses are practically the same in the Freshman year, and differ but slightly in the Sophomore year. The student has thus an opportunity to defer his choice of a specialty until he has spent some time in technical study, and can better estimate his inclinations and capacities.

One hour is given to each recitation or lecture period. The afternoon periods are given to drawing, laboratory, and field work and are of three hours' duration.

GRADUATE COURSES.

The School of Mines offers graduate work in Mining Engineering, Metallurgy, Ore Dressing, Geology, Economic Geology, Petrography, and Advanced Chemistry. The attention of graduates of engineering schools and of mining schools is directed to the following courses:

Mine Management
Mining Machinery
Mining Machinery Laboratory
Mining Machinery Problems
Mining Law and Contracts
Mine Examination and Reports
Mine Plant
Mine Plant Design
Mining Economics
Mining Research
Economic Geology
Geology of the United States
Structural and Metamorphic Geology
Paleontology
Historical Geology
Petrography
Petrography Laboratory
Cement and Concrete Structures
Compressed Air
Engineering Designs
Ore Dressing Laboratory
Ore Dressing Problems
Ore Supply
Metallurgy Organization
Metallography
Constitution of Alloys
Metallurgical Problems
Metallurgical Plant
Metallurgical Plant Design
Cyaniding
Electro-Metallurgy
Electro-Metallurgy Laboratory
Metallurgical Research
Electro-Chemistry
Slag Analysis
Metallurgical Analysis
Technical Analysis
Physical Chemistry
Theoretical Chemistry
Advanced Physico-Chemical Laboratory
Internal Combustion Engines

Graduates from the four-year course in Mining Engineering may pursue graduate work leading to the degree of Mining Engineer. This fifth year course is outlined on page 46. Electives may be chosen along any line aproved by the Faculty.

A similar graduate course in Metallurgy is outlined on page 47. This course leads to the degree of Metallurgical Engineer.

Graduates in Civil, Electrical, and Mechanical Engineering, who desire to specialize in Mining, may secure the degree of Engineer of Mines by completing the course of study outlined on page 48. Considerable latitude will be granted men who are qualified to undertake research work.

SPECIAL COURSES.

In addition to the four regular courses leading to degrees, mentioned above, a number of shorter courses are also offered. They are: *Chemistry and Assaying, Mining, Surveying and Electricity.* They have been planned for the benefit of those who, for various legitimate reasons, are unable to take the regular four-year courses.

The course in *Assaying and Chemistry* requires two years' work, although mature students, who have already some knowledge of chemistry, may complete it in one year.

The purpose of the course in *Surveying* is to develop competent land and mining surveyors and fair draftsmen. The essentials of it are a thorough knowledge of algebra, trigonometry, surveying, field practice, and drawing. One school year and the first term of a second will be required for the completion of this course.

A short course in *Mining* is offered to students, especially such as have had some practical experience, who may wish to fit themselves for holding important positions about mines or in ore-dressing plants, but who are unable, on account of the lack of preparation or of time, to take the full course in Mining Engineering. Besides mathematics this course includes general chemistry, assaying, mineralogy, geology, mining, surveying, and English.

A course in *Electricity* is offered to furnish the student with the theory of electricity, and acquaint him with its application in the arts. This subject is of great importance to every engineer, especially to the mining engineer, since electricity has become such an important factor in mining operations.

EXCURSIONS.

Required.

A.—At the close of the Sophomore year, three weeks of summer field work for practice in topography and lines of communication is required of students in Civil Engineering. This work is carried on in the vicinity of Rolla.

B.—At the opening of the school year, in September, one week's field work in Topography by all Juniors not taking A.

C.—At the close of the Junior year, students in Mining and Metallurgical Engineering make a three weeks' excursion to southeast Missouri, for practice in mine surveying and the study of field and economic geology, mining, and ore dressing.

D.—During the Senior year a one week's trip to southwest Missouri, particularly the Joplin district, for the study of ore deposits, mining methods, and ore dressing.

E.—Excursions by the Senior class to Steelville, Sligo, DeCamp, Meramec, Newburg, and Sullivan for the purpose of studying iron, copper, lead deposits, and methods of reduction. This excursion takes place during the latter part of the Senior year.

F.—An excursion by the Senior class to Herculaneum, St. Louis, Granite City, and the coal fields of Illinois. This excursion is made during the latter part of the Senior year.

Voluntary.

In addition to the foregoing trips which are required in the various courses, a number of optional excursions can be made under the supervision of the members of the Faculty. These excursions are planned for students who have finished the work of the Junior year and may be made to the following mining districts:

1.—Southern Appalachian District, where geology, mining, and metallurgy may be studied, particularly in the mining districts of Birmingham, Ala., and Ducktown, Tenn.

2.—Copper mining districts of the Southwest, particularly Bisbee, Ariz., and Cananea, Mexico.

3.—Lake Superior mining district, including the copper and iron ranges of Michigan and the iron ranges of Minnesota.

4.—Metal mining districts of Colorado, Utah, and Montana.

THESES.

All Seniors carry on special investigations during the third term and the results of this work are embodied in a thesis. The subject of the thesis must be reported to the Thesis Committee and approved not later than February 1st and the completed thesis filed with the Director not later than May 20th. The finished thesis must be typewritten on eight and one-half by eleven-inch paper with a one and one-half inch margin on the left to permit of binding in book form.

DEGREES.

1. The degree of Bachelor of Science in Mining Engineering, Bachelor of Science in Metallurgy, or Bachelor of Science in Civil Engineering, will be conferred on students who have attained the required standard in all the subjects of instruction in Course I., II., or III., and who submit a satisfactory thesis.

2. The degree of Bachelor of Science will be conferred on students who have satisfactorily completed Course IV., and who submit a satisfactory thesis.

3. The degree of Master of Science will be given to students who, having graduated in Course IV., complete satisfactorily a year's post-graduate work in residence at the school, and demonstrate their ability by research work and a thesis.

4. The degree of Engineer of Mines, Civil Engineer, or Metallurgical Engineer, will be conferred on one who, having previously been graduated in Course I., II., or III., has completed satisfactorily a year's post-graduate work in residence, or who has had professional experience in a responsible position for not less than three years. A satisfactory thesis recording the result of some original investigation or independent research in a subject connected with his course, accompanied by such drawings as may be necessary to illustrate it, are required of all candidates for advanced degrees.

COURSE I.—MINING ENGINEERING.

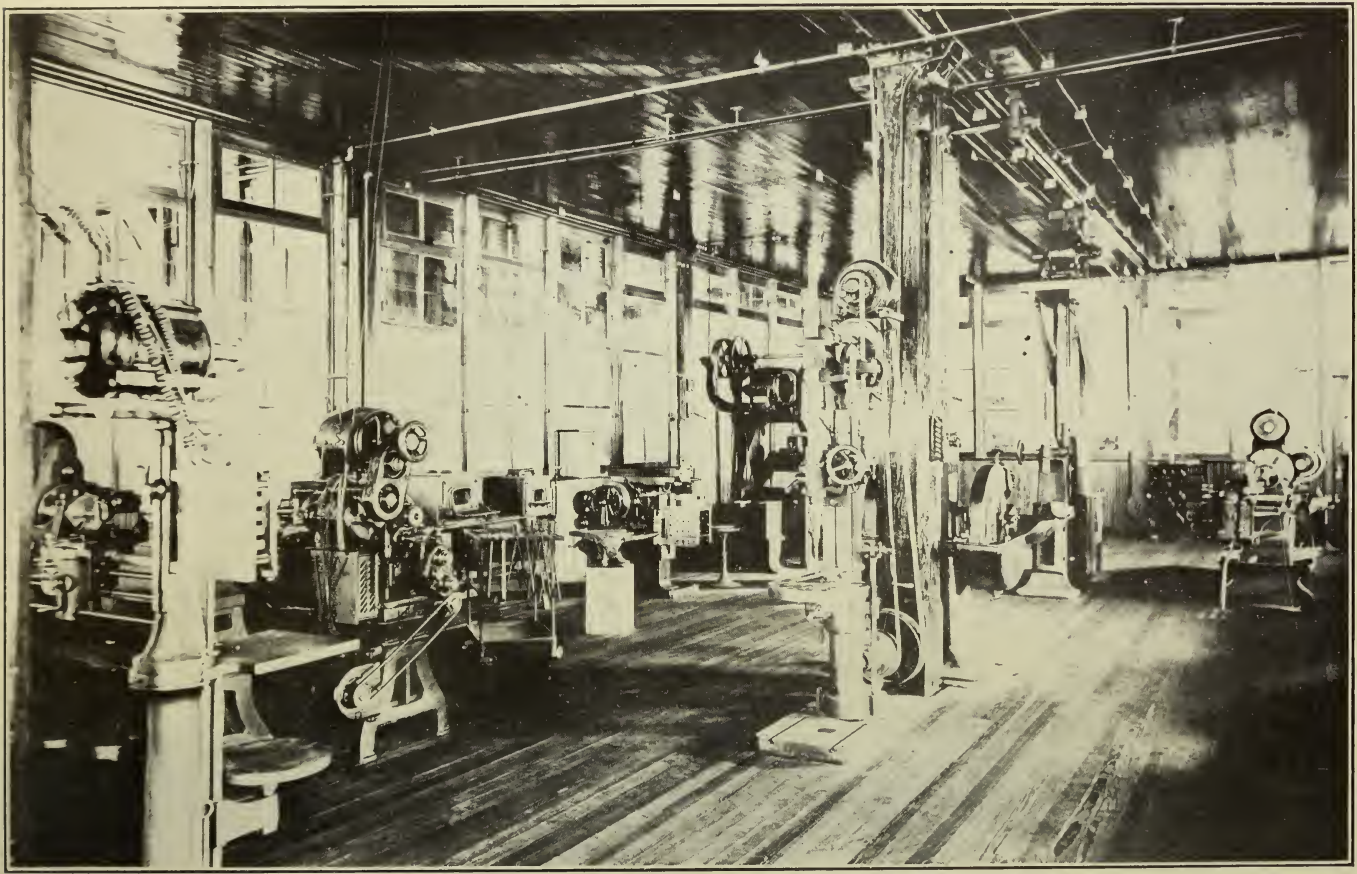
	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FRESHMAN YEAR.			
LECTURES AND RECITATIONS:			
College Algebra	5	—	—
Plane Trigonometry	—	5	—
Spherical Trigonometry	—	—	5
Analytical Geometry			
Descriptive Geometry	—	2	2
General Chemistry	5	5	4
English	5	5	5
Elementary Mining	2	—	—
Mineralogy	—	—	2
LABORATORY WORK:			
General Chemistry	3	3	3
Drawing, Mechanical	6	6	6
Descriptive Geometry Drawing	—	3	3
Shop Practice	6	6	—
Mineralogy Laboratory	—	—	6
SOPHOMORE YEAR.			
LECTURES AND RECITATIONS:			
Analytical Geometry	5	—	—
Differential Calculus			
Spanish, German, or French	5	5	5
Advanced English	1	1	1
Integral Calculus	—	5	—
Differential Equations	—	—	5
Mineralogy	2	—	—
Lithology	—	2	—
Plane Surveying	3	—	—
Mine Surveying	—	—	3
Mining	2	2	—
Elementary Mechanics	—	2	—
General Physics	—	—	5
Qualitative Analysis	—	2	—
LABORATORY WORK:			
Forge Shop or Machine Drawing	6	6	6
Mineralogy	6	6	—
Lithology	—	3	—
Surveying Field Practice	6	—	—
Qualitative Analysis	—	6	6
Physics	—	—	6
Topography, one week between the Sophomore and Junior Years.			

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
JUNIOR YEAR.			
LECTURES AND RECITATIONS:			
General Physics	5	—	—
Thermodynamics	—	5	—
Mechanics of Engineering	5	—	—
Mechanics of Materials	—	5	—
Hydraulics	—	—	5
General Geology	5	3	5
Quantitative Analysis	2	—	—
Assaying	2	—	—
Metallurgy	—	3	3
Masonry	—	2	—
Lines of Communication	—	—	2
Elements of Ore Dressing	—	—	3
LABORATORY WORK:			
Physics	6	—	—
Steam	—	3	—
Assaying	6	6	—
Quantitative Analysis	6	9	—
General Geology	—	3	6
Drawing and Graphics	—	—	6
Lines of Communication	—	—	3
Hydraulic Problems	—	—	3
Excursion to Southeast Missouri.			
SENIOR YEAR.			
LECTURES AND RECITATIONS:			
Ore Dressing	4	4	4
Ore Dressing Memoirs	—	—	1
Mining Law and Contracts	2	—	—
Mine Management	—	—	2
Metallurgy	4	4	4
Metallurgy Conference	—	1	—
Economic Geology	3	3	5
Dynamo Machinery	3	—	—
Alternating Current Machinery	—	5	—
Electrical Transmission	—	—	3
Compressed Air	—	2	—
Frame Structures	2	—	—
Hydraulic Motors and Pumps	—	—	1
LABORATORY WORK:			
Ore Dressing	6	—	—
Ore Dressing Problems	—	3	3
Graphics	3	—	—
Dynamo Machinery	6	—	—
Alternating Current Machinery	—	6	—
Electrical Problems	—	—	3
Metallurgy	—	7	—
Compressed Air	—	3	—
Thesis	—	—	6
Senior Trips.			

MINING GEOLOGY OPTION.

SENIOR YEAR.

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
Lectures and Recitations:			
Economic Geology	3	3	5
Petrography	3	3	2
Geology of the United States	3	—	—
Structural and Metamorphic Geology	—	—	3
Metallurgy	4	4	4
Geological Conference	—	2	—
Ore Dressing	4	4	—
Mining Law and Contracts	2	—	—
Methods of Prospecting and Mine Development	—	3	—
Mine Management	—	—	2
Elective Geology	—	—	3
Laboratory Work:			
Geology	3	6	6
Petrography	9	6	6
Ore Dressing	6	—	—
Metallurgy	—	6	—
Thesis	—	—	6
Senior Trips.			



MACHINE SHOP

MINING MACHINERY OPTION.

SENIOR YEAR.

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
LECTURES AND RECITATIONS:			
Ore Dressing	4	4	4
Ore Dressing Memoirs	—	—	1
Mining Machinery	—	4	5
Dynamo Machinery	3	—	—
Alternating Current Machinery	—	5	—
Electrical Transmission	—	—	3
Compressed Air	—	2	—
Hydraulic Motors and Pumps	—	—	1
Mine Management	—	—	2
Mining Law and Contracts	2	—	—
Economic Geology	3	—	—
Metallurgy	4	4	—
Metallurgy Conference	—	1	—
Frame Structures	2	—	—
Cement and Concrete Structures	—	—	2
LABORATORY WORK:			
Mining Machinery	3	9	—
Mining Machinery Problems	—	—	6
Graphics	3	—	—
Dynamo Machinery	6	—	—
Alternating Current Machinery	—	6	—
Electrical Problems	—	—	3
Ore Dressing	6	—	—
Metallurgy	—	4	—
Compressed Air	—	3	—
Thesis	—	—	6
Senior Trips.			

ORE DRESSING OPTION.

SENIOR YEAR.

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
Lectures and Recitations:			
Ore Dressing	4	4	4
Ore Dressing Memoirs	—	—	1
Mining Law and Contracts	2	—	—
Mine Management	—	—	2
Metallurgy	4	4	4
Metallurgy Conference	—	1	—
Economic Geology	3	3	5
Dynamo Machinery	3	—	—
Alternating Current Machinery	—	5	—
Electrical Transmission	—	—	3
Compressed Air	—	2	—
Frame Structures	2	—	—
Hydraulic Motors and Pumps	—	—	1
Laboratory Work:			
Ore Dressing	9	—	6
Ore Dressing Problems	—	3	3
Graphics	3	—	—
Dynamo Machinery	6	—	—
Alternating Current Machinery	—	6	—
Electrical Problems	—	—	3
Metallurgy	—	7	—
Compressed Air	—	3	—
Thesis	—	—	6
Senior Trips.			

COURSE II.—METALLURGY.

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FRESHMAN YEAR.			
Lectures and Recitations:			
College Algebra	5	—	—
Plane Trigonometry	—	5	—
Spherical Trigonometry Analytical Geometry	—	—	5
General Chemistry	5	5	4
English	5	5	5
Descriptive Geometry	—	2	2
Elementary Mining	2	—	—
Mineralogy	—	—	2
Qualitative Analysis	—	2	—
Laboratory Work:			
General Chemistry	9	—	—
Mechanical Drawing	6	6	6
Qualitative Analysis	—	9	6
Mineralogy	—	—	6
Descriptive Geometry	—	3	3
SOPHOMORE YEAR.			
Lectures and Recitations:			
Analytical Geometry Differential Calculus	5	—	—
Integral Calculus	—	5	—
Differential Equations	—	—	5
German, French, or Spanish	5	5	5
Elementary Mechanics	—	2	—
Advanced English	1	1	1
General Physics	—	—	5
Lithology	—	2	—
Quantitative Analysis	2	2	2
Surveying, Plane	3	—	—
Mineralogy	2	—	—
Laboratory Work:			
Field Practice	6	—	—
Quantitative Analysis	6	9	12
Mineralogy	6	6	—
Lithology	—	3	—
Physics	—	—	6

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
JUNIOR YEAR.			
LECTURES AND RECITATIONS:			
Assaying	2	—	—
General Geology	5	3	5
General Physics	5	—	—
Mechanics of Engineering	5	—	—
Chemical Memoirs	2	—	—
Electro-Chemistry	—	2	3
Mechanics of Materials	—	5	—
Hydraulics	—	—	5
Elements of Ore Dressing	—	—	3
Metallurgy	—	3	3
Physical Chemistry	—	2	—
Thermodynamics	—	5	—
LABORATORY WORK:			
Assaying	6	6	—
Geology	—	3	—
Field Geology	—	—	6
Physics	6	—	—
Quantitative Analysis	6	—	—
Physical Chemistry	—	3	—
Electro-Chemistry	—	3	6
Metallurgy	—	—	3
Hydraulic Problems	—	—	3
Steam	—	3	—
Excursion to Southeast Missouri.			
SENIOR YEAR.			
LECTURES AND RECITATIONS:			
Alloys	2	—	—
Alternating Current Machinery	—	5	—
Dynamo Machinery	3	—	—
Electro-Metallurgy	2	—	—
Contracts	2	—	—
Metallurgical Problems	1	—	1
Metallurgy	4	4	4
Ore Dressing	4	4	4
Compressed Air	—	2	—
Metallurgy Conference	—	1	—
Metallurgical Organization	—	3	—
Electrical Transmission	—	—	3
Memoirs, Chemical and Metallurgical	—	—	1
Hydraulic Motors and Pumps	—	—	1
Technical Chemical Analysis	—	—	1
LABORATORY WORK:			
Metallurgy and Electro-Metallurgy	6	—	—
Ore Dressing	9	—	6
Dynamo Machinery	6	—	—
Compressed Air	—	3	—
Alternating Currents	—	6	—
Metallurgy	—	7	—
Metallography	—	3	—
Electrical Problems	—	—	3
Technical Analysis (Chemical)	—	—	3
Thesis	—	—	6
Senior Trips.			

COURSE III.—CIVIL ENGINEERING.

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FRESHMAN YEAR.			
Lectures and Recitations:			
College Algebra	5	—	—
General Chemistry	5	5	4
English	5	5	5
Descriptive Geometry	—	2	2
Elementary Mining	2	—	—
Plane Trigonometry	—	5	—
Spherical Trigonometry	—	—	5
Analytical Geometry			
Mineralogy	—	—	2
Laboratory Work:			
General Chemistry	3	3	3
Descriptive Geometry Drawing	—	3	3
Mechanical Drawing	6	6	6
Shop Practice	6	6	—
Mineralogy	—	—	6
SOPHOMORE YEAR.			
Lectures and Recitations:			
Analytical Geometry	5	—	—
Differential Calculus			
Integral Calculus	—	5	—
Differential Equations	—	—	5
Advanced English	1	1	1
Spanish, German, or French	5	5	5
Elementary Mechanics	—	2	—
Plane Surveying	3	—	—
Mine Surveying	—	—	3
General Physics	—	—	5
Lines of Communication	—	—	2
Geodesy	—	3	—
Laboratory Work:			
Field Practice	9	—	9
Forge Shop or Machine Drawing	6	6	—
Geodesy and Computations	—	9	—
Physics	—	—	6
Topography, one week.			

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
JUNIOR YEAR.			
LECTURES AND RECITATIONS:			
Astronomy	—	—	2
General Geology	5	3	5
Hydraulics	—	—	5
Mechanics of Engineering	5	—	—
Masonry	—	2	—
Mechanics of Materials	—	5	—
Metallurgy of Iron and Steel	—	—	3
General Physics	5	—	—
Lines of Communication	3	—	—
Thermodynamics	—	5	—
Roads and Pavements	—	—	2
Graphics	—	2	—
LABORATORY WORK:			
Drawing and Graphics	—	—	6
Hydraulic Problems	—	—	3
General Geology	—	3	6
Field Practice	9	—	—
Engineering Laboratory and Graphics	—	12	—
Physics	6	—	—
Steam	—	3	—
SENIOR YEAR.			
LECTURES AND RECITATIONS:			
Alternating Current Machinery	—	5	—
Bridges (Higher Structures)	—	5	—
Compressed Air	—	2	—
Dynamo Machinery	3	—	—
Economic Geology	3	—	—
Electrical Transmission	—	—	3
Estimates and Bidding	—	—	2
Frame Structures	2	—	—
Hydraulic Motors and Pumps	—	—	1
Irrigation	—	—	3
Masonry Design and Concrete Steel	—	—	5
Mining Law and Contracts	2	—	—
River and Harbor Improvements	—	—	2
Railroad Economics	3	—	—
Sanitary Engineering	—	5	—
Water Supply	5	—	—
LABORATORY WORK:			
Dynamo Machinery	6	—	—
Alternating Current Machinery	—	5	—
Compressed Air	—	3	—
Designing	—	6	6
Graphics and Engineering Designs	9	—	—
Electrical Problems	—	—	3
Thesis	—	—	6

COURSE IV.—GENERAL SCIENCE.

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FRESHMAN YEAR.			
LECTURES AND RECITATIONS:			
College Algebra	5	—	—
General Chemistry	5	5	4
English	5	5	5
Elementary Mining	2	—	—
German	—	4	4
Mineralogy	—	—	2
Plane Trigonometry	—	5	—
Spherical Trigonometry Analytical Geometry	—	—	5
LABORATORY WORK:			
Drawing	6	6	6
General Chemistry	3	3	3
Mineralogy	—	—	6
Elective	6	6	—
SOPHOMORE YEAR.			
LECTURES AND RECITATIONS:			
German	5	5	5
English	5	5	5
Elementary Mechanics	—	2	—
Qualitative Analysis	—	2	—
Mineralogy	2	—	—
Elective	6	4	8
LABORATORY WORK:			
Qualitative Analysis	—	6	6
Mineralogy	6	6	—
Physics	—	—	6
Elective	9	6	3
JUNIOR YEAR.			
LECTURES AND RECITATIONS:			
French or Spanish	5	5	5
General Geology	5	3	5
General Physics	5	—	—
Elective	3	10	8
LABORATORY WORK:			
General Geology	—	3	6
General Physics	6	—	—
Elective	9	12	9

SENIOR YEAR.

All elective.

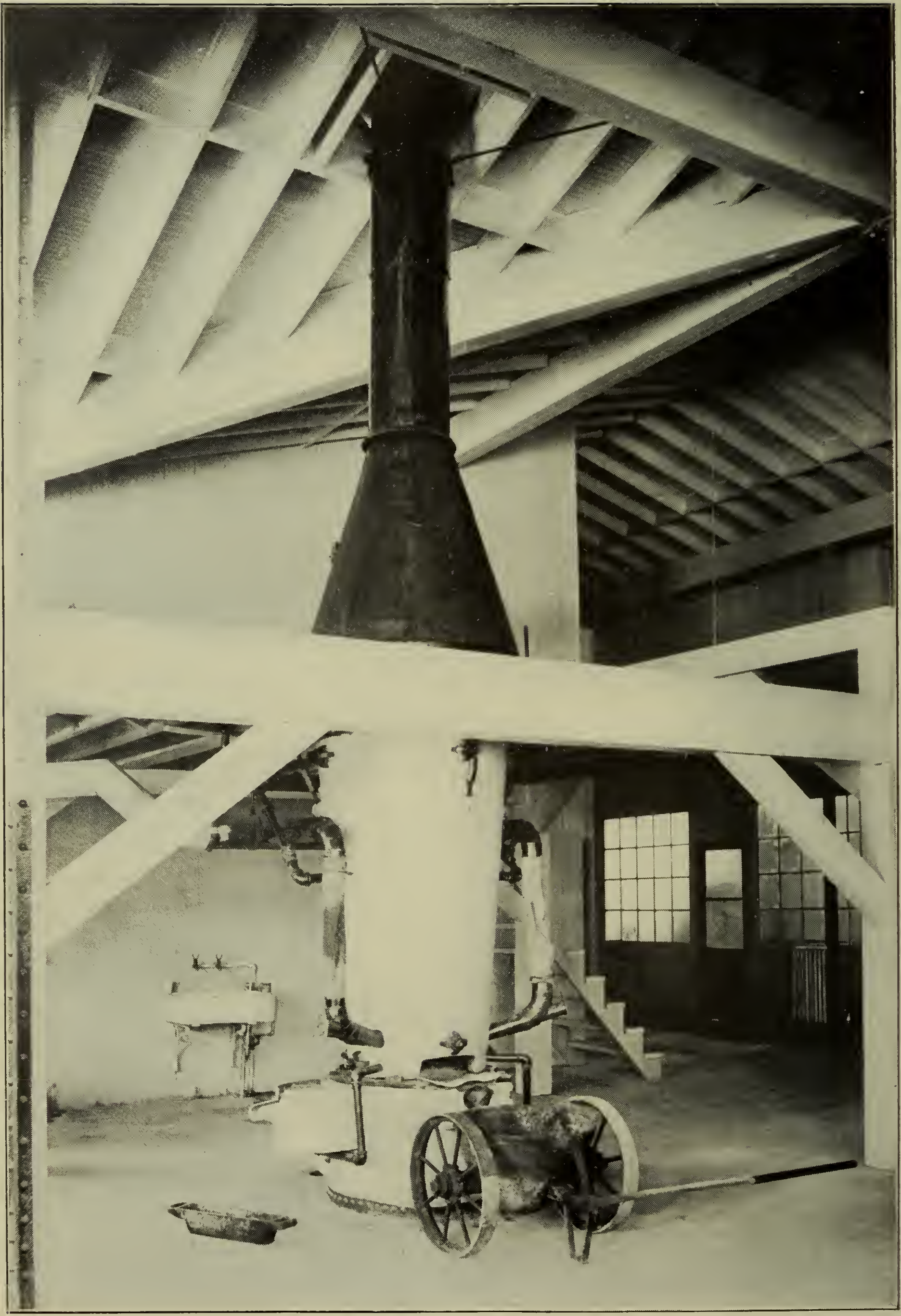
The selection of studies is subject to the approval of the Faculty.

Electives after the Sophomore year must be along one of the two lines: Physics and Mathematics, or Chemistry and Geology. Twenty-three hours recitation, or eighteen hours recitation and five afternoons laboratory work a week, constitute a course.

GRADUATE COURSE IN MINE ENGINEERING.*

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
Lectures and Recitations:			
Mining Research	5	5	5
Mine Examination and Reports	—	3	—
Mine Plant	—	3	—
Mining Machinery	—	4	5
Mining Economics	—	—	2
Metallurgical Problems	1	—	1
Geology of the United States	3	—	—
Structural and Metamorphic Geology	—	—	3
Cement and Concrete Structures	—	—	2
Internal Combustion Engines	3	—	—
Electives	6	3	—
Laboratory Work:			
Mill Plant Design	—	3	9
Mining Machinery	3	9	—
Electives	9	—	—
Thesis	3	6	6

*These courses are open to students holding the degree of Bachelor of Science in Mine Engineering. The degree of Engineer of Mines will be conferred upon those who complete the course outlined.



WATER-JACKET BLAST-FURNACE

GRADUATE COURSE IN METALLURGY.*

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
Lectures and Recitations:			
Metallurgical Research	5	5	5
Cyaniding	3	3	—
Metallurgy Plant	—	3	—
Theoretical Chemistry	2	2	2
Ore Supply	—	—	3
Geology of the United States	3	—	—
Mining Economics	—	—	2
Cement and Concrete Structures	—	—	2
Internal Combustion Engines	3	—	—
Laboratory Work:			
Metallurgy Plant Design	—	3	9
Cyanide Laboratory	6	6	—
Advanced Chemistry Laboratory	6	6	—
Thesis	3	6	6

*These courses are open to students holding the degree of Bachelor of Science in Metallurgy. The degree of Metallurgical Engineer will be conferred upon those who complete the course outlined.

GRADUATE COURSE FOR ENGINEERS.*

	TIME IN HOURS PER WEEK.		
	FIRST TERM.	SECOND TERM.	THIRD TERM.
FIRST YEAR.			
LECTURES AND RECITATIONS:			
Mine Surveying	—	—	3
Geology	5	3	5
Mineralogy	3	—	—
Lithology	—	2	—
Qualitative Analysis	—	2	—
Assaying	2	—	—
Ore Dressing	—	—	3
Mining	2	2	—
Metallurgy	—	3	3
Elective	6	6	4
LABORATORY WORK:			
Mineralogy	12	6	—
Lithology	—	3	—
Geology	—	3	6
Qualitative Analysis	—	6	6
Assaying	—	—	9
Elective	3	3	—
SECOND YEAR.			
LECTURES AND RECITATIONS:			
Compressed Air	—	2	—
Quantitative Analysis	2	—	—
Economic Geology	3	3	5
Metallurgy	4	4	4
Metallurgy Conference	—	1	—
Ore Dressing	4	3	—
Ore Dressing Memoirs	—	—	1
Mining Law and Contracts	2	—	—
Mine Management	—	—	2
Elective	3	5	5
LABORATORY WORK:			
Quantitative Analysis	6	9	—
Ore Dressing	6	—	3
Compressed Air	—	3	—
Geology	3	—	3
Metallography	—	3	—
Mining Problems	—	—	3
Thesis	—	—	6
Elective	3	3	3

*This two-year course is planned for graduates in Civil, Electrical, or Mechanical Engineering, who desire to work along mining lines. The degree, Mining Engineer, will be conferred on students who have received the Bachelor of Science Degree in Engineering, and who complete the two-year course as outlined.

MATHEMATICS.

Professor Dean, Assistant Professor Garrett,
Mr. Forrester.

While the utility of mathematical study as a mental discipline is duly recognized, the ultimate intention of the student is kept in mind, and the matter and the method of the courses are adjusted to meet the demands of subsequent studies in pure and applied science. Daily drill in the class-room is an important feature of the work.

Students who bring credits from other colleges will be allowed to enter with advanced standing only when the courses can be shown to be equivalent to those given here, and then only conditionally. Those who fail to do creditable work in the courses undertaken will be required to drop such courses and take up more elementary work.

1. *College Algebra.*—The time allotted for this course being very short, only such work is given as is found absolutely necessary to prepare for subsequent studies.

Prerequisites: Entrance requirements.

Freshman year, first term, five hours per week.

Text: Hall and Knight, Algebra for Schools and Colleges.

2. *Plane Trigonometry.*—This subject is the most important in the mathematical equipment of the engineer. The student is drilled, not only in the solution of triangles and other geometrical problems, but in the application of the trigonometric functions to analysis and in shortening computations.

Prerequisite: College Algebra.

Freshman year, second term, five hours per week.

Text: Taylor and Puryear, *Trigonometry.*

3. *Spherical Trigonometry.*—This course is limited to practical applications in astronomy, geodesy, and mine surveying.

Prerequisite: Plane Trigonometry.

Freshman year, first two weeks of third term, five hours per week.

Text: Comstock, *Field Astronomy for Engineers.*
Taylor and Puryear, *Trigonometry.*

4. *Analytical Geometry.*—This course includes the study of the straight line, the circle, and special forms of the equations of the conic sections.

Prerequisites: Plane and Spherical Trigonometry.

Freshman year, third term after Course 3, five hours per week.

Text: Ashton, *Analytic Geometry.*

5. *Analytical Geometry.*—This is a continuation of Course 4 and includes the study of the general equation of the second degree, general theorems on conic sections, and the higher plane curves, such as the catenary, cycloid, and spirals.

Prerequisite: Course 4.

Sophomore year, first four weeks of the first term, five hours per week.

Text: Dean, *Manuscript Notes and Lectures.*

6. *Differential Calculus.*—The student is given a thorough drill in the derivation of formulae, and application of derivatives and differentials, in the solution of problems in maxima and minima, curve tracing, rates, velocities and accelerations, and expansion of functions.

Prerequisites: Courses 2 and 3.

Sophomore year, first term, five hours per week, following Course 6.

Texts: Osborn, *Calculus.*
Granville, *Calculus.*
Dean, *Manuscript Notes.*

7. *Integral Calculus.*—Attention is paid largely to attaining as much skill as possible in integration of forms occurring in mechanics and physics. As the student acquires his fund of knowledge and experience, he is drilled in evaluating areas,

lengths of curves, moments of inertia, centers of gravity, and fundamental formulae of hydraulics and hydrostatics.

Prerequisite: Course 6.

Sophomore year, second term, five hours per week.

Texts: Osborn, *Calculus.*
Granville, *Calculus.*
Dean, *Manuscript Notes.*

8. *Differential Equations.*—A continuation of Course 7, taking up more difficult problems and higher developments of the subject, dynamics of a particle, theory of attraction, and thermodynamics of perfect gases.

Prerequisite: Course 7.

Sophomore year, third term, five hours per week.

Texts: Cohen, *Differential Equations.*
Dean, *Manuscript Notes.*

9. *Mechanics of Engineering.*—It is the aim to develop the essential principles of mechanics and to train the student to be proficient in applying them to practical, rather than to theoretical, problems. A large number of problems are solved which, so far as possible, are selected from machines or structures with which the student is already familiar, or the study of which he is to take up subsequently.

Prerequisites: Courses 6 and 7.

Junior year, first term, five hours per week.

Text: Hancock, *Applied Mechanics for Engineers.*

10. *Mechanics of Materials.*—A study of the theory of stress, strain and elasticity and its application to the design of members of machines and structures; a discussion of the properties of the materials of engineering construction.

Prerequisite: Course 9.

Junior year, second term, five hours per week.

Text: Slocum and Hancock, *Strength of Materials.*

Elective Work.

Students in the General Science Course who elect work in pure mathematics will confer with the head of the department, who will arrange work according to the needs, tastes, and aptitudes of the applicants.

The following courses are offered to students who have all the required work in mathematics, mechanics, and general physics:

1. Dynamics of Particles and Rigid Bodies.
2. Hydrodynamics.
3. Mathematical Theory of Elasticity.
4. Newtonian Potential Function.
5. Harmonic Functions.
6. Theory of Least Squares.
7. Differential Equations of Mechanics and Physics.
8. Mechanics of Hoisting Machinery.

CHEMICAL HALL

CHEMISTRY.

Professor Gottschalk, Assistant Professor Test, Mr. Barrett, Mr. Walker, Mr. Riede, Mr. Lane.

Equipment.

One entire building is given to chemistry. The main chemical lecture room occupies the entire south wing of the building and contains a long lecture desk, with gas and water connections for lecture experiments, and a large glass hood and side desks fit it for demonstration purposes for large classes. The general chemical laboratories contain the lockers and desks for one hundred students.

The qualitative analysis laboratory provides desk space for forty students working at one time. A long line of hoods extends along two walls of the room. Air blast is provided and the room is well ventilated by means of a blower. The entire second floor of the building is used for quantitative analysis. The main laboratory will accommodate seventy-five students at one time. Gas and water are supplied conveniently and compressed air furnishes blast for thirteen blast lamps. The balance rooms on the north side of the building contain nineteen first-class balances.

There are several private and research laboratories on both floors.

Courses.

1. *General Chemistry.*—This course is a comprehensive study of the general principles of chemistry and of the more important elements. Special attention is paid to the chemistry of the metals. The Periodic law is followed throughout. The lectures are fully illustrated; the class is divided into several smaller sections for recitations.

Prerequisites: Entrance requirements.

Freshman year, first and second terms, five hours per week; third term, four hours per week.

Text: Kahlenberg, *Inorganic Chemistry.*

2. *General Chemistry Laboratory.*—The laboratory work accompanying general chemistry consists of experiments, which are largely quantitative, and which are intended to teach stoichiometrical relations from the first.

Prerequisites: Entrance requirements. To accompany Course 1.

Freshman year, one afternoon per week throughout the year, Civil Engineering and Mining Engineering Courses; first term, three afternoons per week, Metallurgy Course and Special Courses in Mining, Surveying, and Assaying.

Text: Ransom, and *Manuscript Notes.*

3. *Qualitative Analysis.*—This course includes lectures and laboratory work; the laboratory work includes the tests and separation of the more common metallic elements; analysis of solutions containing phosphates, of alkaline solutions, of insoluble substances, of alloys, of natural products, and of slags; also blow-pipe analysis.

Prerequisites: General Chemistry Lectures and Current Lectures and General Chemistry Laboratory.

Lectures, Sophomore year, second term, two hours per week, Mining Engineering and General Science Courses; Freshman year, second term, two hours per week, Metallurgy Course and Special Courses in Mining and Assaying.

Laboratory work, Sophomore year, second and third terms, two afternoons per week, Mining Engineering and General Science Courses; Freshman year, third term, two afternoons per week, Metallurgy Course; first year, second and third terms, three afternoons per week, Special Courses in Mining and Assaying.

The same course is given in the summer school.

Text: Tower, *Qualitative Analysis.*

4. *Quantitative Analysis.*—Introductory Course.—This work begins with a study of the balance; this is followed by accurate gravimetric analysis, first on pure soluble salts, then on natural products; then by accurate volumetric analysis (acidimetry, alkalimetry, iron by the permanganate method).

As samples of technical work, the wet assays, as practiced in the West, are studied during the latter half of the course.

Prerequisites: Courses 1, 2, and 3.

Lectures, Junior year, first term, two hours per week, Mining Engineering Course; Sophomore year, first term, two hours per week, Metallurgical Course and Special Course in Mining and Assaying.

Laboratory work, Junior year, first term, two afternoons per week; second term, three afternoons per week, Mining Engineering Course; Sophomore year, first term, two afternoons per week; second term, three afternoons per week, Metallurgy Course; second year, first term, two afternoons per week; second term, three afternoons per week, Special Courses in Mining, Chemistry, and Assaying.

The same course is given in the summer school.

Text: Miller, *Quantitative Analysis for Mining Engineers.*

5. *Quantitative Analysis Lectures.*—This lecture course comprises a complete exposition of the general methods and details of manipulation of analysis, theory of instruments used, general chemical theory not included in Freshman chemistry, and the discussion of the sources of error, including testing, purification, and preparation of reagents.

Prerequisite: Course 4.

Sophomore year, second and third terms, two hours per week, Metallurgy Course.

Text: Ostwald, *Foundations of Analytical Chemistry.*

6. *Quantitative Analysis* (*Advanced*).—This course is planned to train the student in general methods of technical analysis.

Prerequisite: Course 4.

Laboratory work, second year, third term, two afternoons per week, Special Course in Chemistry, Mining and Assaying.

7. *Slag Analysis.*—This course presents the methods for complete analysis of slags of various kinds.

Prerequisites: Courses 4 and 5.

Laboratory work, Sophomore year, third term, four afternoons per week, Metallurgy Course.

Text: Low, *Technical Methods of Ore Analysis.*

8. *Metallurgical Analysis.*—Advanced quantitative analysis in its application to metallurgy and metallurgical processes is presented in the laboratory.

Prerequisite: Course 7.

Laboratory work, Junior year, first term, two afternoons per week, Metallurgy Course.

9. *Technical Analysis.*—This is an advanced and applied course in quantitative analysis.

Prerequisite: Course 8.

Senior year, third term, one hour per week, Metallurgy Course.

Laboratory work, Senior year, third term, one afternoon per week, Metallurgy Course.

10. *Chemical Memoirs.*—Carefully prepared abstracts of current articles or of special subjects are prepared by the students for this course.

Prerequisites: Courses 1 to 5, 11 and 12.

Reports, Junior year, third term, three hours per week, Metallurgy Course.

11. *Electro-Chemistry.*—This course includes a theoretical introduction of the study of electro-chemistry and is followed by applications of principles.

Prerequisites: Courses 1 to 5, and 12.

Junior year, second term, four hours per week, Metallurgy Course.

Laboratory work, Junior year, second term, two afternoons per week, Metallurgy Course.

Text: Ewell's *Physical Chemistry.*

12. *Physical Chemistry.*—This is a short course, designed mainly as an introduction to the various kinds of chemical equilibria encountered in metallurgical practice.

Prerequisites: Courses 1 to 5.

Junior year, first term, two hours per week, Metallurgy Course.

Laboratory work, Junior year, first term, two afternoons per week, Metallurgy Course.

Text: Ewell's *Physical Chemistry.*
Manuscript Notes.

Graduate Courses.

13. *Theoretical Chemistry.*—The applications of theoretical chemistry to fundamental metallurgical principles are assuming such prominence and leading to such important results that a knowledge of this subject is indispensable to the metallurgical engineer who desires to keep pace with the developments in this field. To meet this demand a course for graduate students is offered, presenting the subject of chemical equilibria from the thermodynamic point of view, including a consideration of the technical applications made by Nernst, Le Chatelier, Haber, von Jueptner and others. The student is expected to do considerable reading of original articles in English, German, and French scientific journals and books.

Prerequisites: Courses 11 and 12.

Graduate Course, first and second terms, two hours per week.

14. *Advanced Physico-Chemical Laboratory.*—This is an advanced course to accompany the lectures in Theoretical Chemistry, and includes the study and measurements of typical chemical equilibria, either as a repetition of classical researches in this field, or preferably on original problems. The equipment for this work includes measuring instruments of the most approved types for high temperature, electro-thermic and physico-chemical work, and special apparatus built in the school shops.

Prerequisites: Courses 11 and 12. To accompany Course 13.

Graduate Course, first and second terms, two afternoons per week.

PHYSICS.

PROFESSOR MCRAE; MR. BRANHAM.

Equipment.

The lecture room and laboratories for Physics and Electricity are in Norwood Hall. The lecture room will seat one hundred students and is provided with water, gas, and electric connections for conveniences in lecture demonstrations and experiments.

The physical laboratory is on the ground, or basement, floor. There are two large laboratories, one equipped for general physical measurements in mechanics, sound, and heat, and one equipped for electric measurements. There is a battery room equipped with both primary and secondary batteries connected by wires with the various laboratories and the lecture room; a constant-temperature room with double walls and air space insulation; a commodious dark-room with blackened walls for spectrometric and photometric measurements, and a special laboratory for research work.

The equipment includes a Rowland electro-dynamometer with shunts and resistances; a Leeds & Northrup decade wheatstone bridge; a Queen & Co. postoffice pattern wheatstone bridge; two portable testing sets; various wheatstone bridges and resistance boxes; standards of resistance, inductance and capacity; a Lummer-Brodhun photometer; a Gaertner dividing engine, with linear and circular attachments; a Threlfall micromanometer; a Duddell thermo galvanometer; various tangent, mirror and D'Arsonval galvanometers; a Parr coal calorimeter; a wireless telegraph demonstration set; a ten-inch induction coil; Crooke's tubes; X-ray tubes; Toepler Holtz machine; a Schmidt & Haensch spectrometer; a Rowland diffraction grating; photographs of Rowland's normal solar spectrum; Crosby, and Schaeffer and Budenberg steam and gas engine indicators; Amsler planimeters; tachometers and speed counters; various balances; micrometers, calipers, together with apparatus for illustrating the principles of physics.

The dynamo laboratory contains an assortment of direct-current generators and motors, a General Electric double-current generator for direct current and alternating current work, a single and a three-phase generator, an induction motor, a rotary transformer, stationary transformers, three-phase to two-phase transformers, and a Cooper-Hewitt mercury vapor converter with testing instruments, which include a Weston laboratory standard voltmeter, with multipliers; a Weston laboratory standard milli-voltmeter, with shunts; a Kelvin electrostatic voltmeter; Weston portable direct-current ammeters; Weston portable direct-current and alternating current voltmeter; Weston and Thomson portable wattmeters; Thomson alternating-current voltmeters; Westinghouse portable polyphase wattmeter; Westinghouse portable voltmeter with transformer; Westinghouse portable ammeter with series transformer; electro-dynamometers; a Grassot fluxmeter; inductance coils, and condensers.

The power-plant also is used for experimental purposes, and comprises a strictly modern and thoroughly equipped laboratory. The machinery available for testing purposes includes three 130-h. p. Heine safety boilers. The steam engines include a 75-h. p. Ideal engine, a 35-h. p. Brownell engine, and a 7-h. p. Davis & Rankin vertical engine. A 15-h. p. Otto gas engine may be belted to electric generators or used for experimental purposes. The pneumatic equipment includes a Laidlaw-Dunn-Gordon air compressor, a Rand Imperial type air compressor, a 72-inch ventilating fan, a 36-inch ventilating fan, and a 60-inch Buffalo forge blower. There are six pumps of three different patterns, which can be used for power or experimental purposes. The electric generators include a 50-kw. Westinghouse 220-volt direct-current generator, a 3½-kw. 120-volt generator, a 7½-kw. General Electric direct and alternating-current generator, a 2-kw. three-phase Westinghouse generator, and a 1-kw. Westinghouse single-phase generator.

The various electrical motors used for power purposes in the shops and laboratories are available for testing in addition to the machinery in the dynamo laboratory. The total electrical equipment includes thirty-five motors, varying in size from ½-h. p. to 30-h. p., with the aggregate rating of 150-h. p.

Courses.

1. *Elementary Mechanics.*—This subject includes the study of the simple machines and the fundamental principles of mechanics and hydrostatics. Lectures and recitations.

Prerequisite: Trigonometry.

Sophomores, second term, two hours per week.

Text: Merriman, *Elements of Mechanics.*

2. *Electricity and Magnetism.*—This course is designed as an introduction of the study of electricity and magnetism.

Prerequisite: Trigonometry.

Lectures and recitations, second term, three hours per week.

Text: S. P. Thompson, *Lessons in Electricity and Magnetism.*

3. *Laboratory Work in Electricity and Magnetism.*—Three afternoons per week throughout the year.

To accompany Course 2.

4a. *General Physics.*—The work in general physics begins with the study of kinematics, statics, kinetics, and the mechanics of fluids. The first term's work concludes with the study of heat, including an introduction of thermodynamics. Particular attention is paid to harmonic motion as the basis for the study of such subjects as sound, light, and alternating currents of electricity.

Prerequisite: Elementary Mechanics. To be preceded by or accompanied by Calculus.

Sophomore year, third term, five hours per week.

Text: Watson, *General Physics.*

4b. *General Physics.*—This course is a continuation of 4a and includes the study of electricity and magnetism, sound, and light. The following subjects are presented in the study of electricity and magnetism: Static electrification, potential, quantity, capacity, resistance, induction, impedance, inductive capacity, and electric waves. During the latter part of the term the reflection, refraction, diffraction, and interference of sound and light are studied. The entire course is illustrated by lecture experiments and supplemented by work in the laboratory.

Prerequisite: Elementary Mechanics. To be preceded by or accompanied by Calculus.

Junior year, first term, five hours per week.

Text: Watson, *General Physics*.

5. *Laboratory Work in Mechanics, Sound, Light, Heat, Electricity, and Magnetism.*—In the laboratory the work is quantitative and aims, as far as possible, to instruct the student in the methods of physical measurement and the derivation of relations between the quantities measured. Emphasis is laid upon the derivation of physical laws rather than the verification of them.

To accompany Courses 4a and 4b.

Sophomore year, third term, two afternoons per week; Junior year, first term, two afternoons per week.

6. *Thermodynamics.*—A short course in theoretical thermodynamics is followed by a study of boilers, furnaces, and heat engines, standard types of safety and tubular boilers, chimney and mechanical draft, pumps and heaters. Steam, gas, and gasoline engines are also studied. Recitations and lectures are supplemented by the equivalent of one afternoon per week in the steam laboratory, where practice is had in operating and indicating engines; measuring chimney draft, boiler evaporation, and the calorific value of fuels.

Prerequisite: Course 4a.

Junior year, second term, five hours per week; laboratory work, second term, one afternoon per week.

Text: Reeve, *Thermodynamics*.

7. *Dynamo Machinery.*—This course discusses the magnetic circuit of dynamos and motors, with methods of connecting for operation in series and parallel; characteristic curves, and methods of testing dynamos and motors.

Prerequisites: Courses 4b and 5.

Senior year, first term, three hours per week.

Text: Sheldon, *Dynamo Machinery.*

8. *Alternating Current Machinery.*—In this course typical single and polyphase generators, synchronous and induction motors, stationary and rotary transformers, are studied. The effect of frequency, induction, and capacity upon the impedance of circuit are presented by the graphical and analytical solution of numerous problems in transmission and distribution.

Prerequisite: Course 7.

Senior year, second term, five hours per week.

Text: Sheldon and Mason, *Alternating Current Machinery.*

9. *Electrical Transmission.*—This course includes the continuous current circuit, single and polyphase alternating current transmission, series and parallel distribution, design of the conducting system, and overhead and underground construction. Lectures and recitations supplemented by one afternoon per week in electrical problems.

Prerequisites: Courses 8 and 10.

Senior year, third term, three hours per week.

10. *Dynamo Laboratory.*—During the first term the work is in connection with the course in dynamo machinery and during the second term it is in connection with the course in alternating current machinery. The work includes the calibration of instruments, characteristic curves, efficiency tests of dynamos, motors, transformers, converters, line resistance capacity, inductance, impedance, and insulation measurements.

Prerequisites: Courses 4a, 4b, and 5. To accompany Courses 7 and 8.

Senior year, first and second terms, two afternoons per week.

Elective Courses.

11. *Theory of Electricity and Magnetism.*—In this course a mathematical treatment of electricity and magnetism is presented for graduates and advanced undergraduates.

Prerequisite: Course 4b.

First and second terms, three hours per week.

12. *Alternating Currents.*—This course supplements Course 8, and includes a rigorous analytical treatment of the subject as well as a study of various practical applications in mining and metallurgy.

Prerequisite: Course 8.

First and second terms, two hours per week.

13. *Internal Combustion Engines.*—This course includes the theory of internal combustion engines together with their practical application in mining operations and in metallurgical industries. It must be preceded by the course in thermodynamics.

Prerequisite: Course 6.

Graduate Course, first term, three hours per week.

CIVIL ENGINEERING.

PROFESSOR HARRIS, MR. MCVEY, MR. DENNIE, MR. MINOR.

Equipment.

Two large drafting rooms amply lighted and equipped for the work above the Freshman year, a blue-print room, two large lecture rooms, and a department library and study are located on the third floor of Norwood Hall.

The equipment for field practice includes thirteen transits and one theodolite, one plane table, one solar compass, one railroad compass, eleven levels, together with barometers, telemeters, chains, tapes, level rods, tools, and other necessary equipment for field practice. A number of the transits are adapted for underground surveying.

The instrument room is located on the first floor of Machinery Building and is equipped with separate lockers for the equipment of each surveying squad.

The testing laboratory is located in the basement of Norwood Hall and is equipped with suitable machinery for making tests on engineering materials.

Courses.

1. *Surveying.*—A course in general surveying, including the use of the transit, the level, and the solar compass. Students are required to plot to scale the areas surveyed and to complete the map in all its details. Following this work, city surveying and topographic methods are taught.

Prerequisite: Trigonometry and Mechanical Drawing.

Sophomore year, first term, three hours per week, Mining Engineering and Civil Engineering courses.

1a. *Field Practice.*—Students in Civil Engineering have field practice three afternoons per week during the first and third terms of the Sophomore year; the other students in surveying have field practice two afternoons per week during the first term of the Sophomore year.

To accompany Course 1.

1b. *Topography.*—The students are divided into parties, each with a captain, and to each is assigned an area to be covered. One week is given to this work in the Sophomore year. From notes so taken, the Civil Engineering students are required to produce a finished topographic map in the first term of the Junior year. Field practice only required in Mining Engineering Course.

Prerequisites: Courses 1 and 1a.

1c. *Geodesy.*—The student studies higher problems in surveying, including engineering astronomy, baseline measurements, and precise leveling.

Prerequisites: Courses 1, 1a, and 1b.

Sophomore year, second term, three hours per week, Civil Engineering Course only.

1d. *Geodesy—Computations and Drawings.*—The student is given exercises in mapping and platting, in the determination of areas, and in the partition of land. He learns to solve systematically the problems in geodesy.

To accompany Course 1c.

Sophomore year, second term, three afternoons per week, Civil Engineering Course only.

2. *Lines of Communication.*—Covers the mathematical problems in the location of railways, highways, and canals, and in setting out and estimating earthwork, laying out track, and locating tunnels.

Prerequisites: Courses 1, 1a, 1b.

Sophomore year, third term, lectures and recitations two hours per week, Civil Engineering Course; Junior year, third term, lectures and recitations two hours per week, Mining Engineering Course.

Field Practice, Sophomore year, third term, three afternoons per week, Civil Engineering Course; Junior year, third term, one afternoon per week, Mining Engineering Course.

3. *Railway Economics.*—Treats of the economic principles of railway location and improvements of old lines as affected by curvature grades, first cost, cost of maintenance, and traffic.

Prerequisite: Course 2.

Senior year, first term, two hours per week, Civil Engineering Course only.

4. *Masonry Construction.*—Treats of the economic properties of building stone, brick, and cement; the proportioning, mixing, and placing of mortars and concrete; preparation of foundations and strength and stability of masonry structures, including dams, piers, abutments, retaining walls, and arches.
Prerequisite: Mechanics of Engineering.

Junior year, second term, two hours per week, Mining Engineering and Civil Engineering Courses.

5. *Engineering Laboratory.*—Includes tests determining the strength and properties of building materials of various kinds, including stone, brick, cement, concrete, cast-iron, steel, and wood. Special attention is paid to tests of cement and cement mortar and concrete.
Prerequisite: Mechanics of Materials.

Junior year, second term, two afternoons per week, Civil Engineering Course only.

6. *Roads and Pavements.*—A discussion of the principles involved in the location and construction of highways, streets, and roads, and the merits of the various methods of paving.
Prerequisite: Course 4.

Junior year, second term, two hours per week, Civil Engineering Course only.

7. *Masonry Designs and Concrete Steel.*—Treats of the higher structures in masonry, including arches, dams, and portals, and the art and theory of concrete-steel structures. The properties, uses, and economy of cement are discussed. The student is required to prepare drawings and specifications of as many structures as possible during the time available.
Prerequisites: Courses 4 and 13.

Senior year, third term, five hours per week, Civil Engineering Course only.

8. *Hydraulics.*—Covers the theory of hydrostatics and of hydraulics; the determination of experimental co-efficients and their use as applied to the flow of water through orifices, weirs, pipes, and canals. Also the theory of hydraulic motors and dynamic pumps.

Prerequisite: Mechanics of Engineering.

Junior year, third term, five hours per week, lectures; one afternoon per week, Hydraulic Problems.

9. *Water Supply.*—Covers the selection, impounding, transporting, purification, and delivering of water supply to cities and towns.

Prerequisite: Course 8.

Senior year, first term, five hours per week, Civil Engineering Course only.

10. *Sanitary Engineering.*—Treats of the necessary precautions for the protection of water supplies from pollution and the methods available for the purification of contaminated supplies. It also includes a study of the principles involved in the collection and disposal of sewage and storm waters, and sewer construction.

Prerequisite: Course 9.

Senior year, second term, lectures and recitations five hours per week, Civil Engineering Course only.

11. *Irrigation.*—Designed to emphasize essential details of the location of canals, headworks, impounding reservoirs, and supplementary work.

Prerequisites: Courses 1, 1a, 1b, 4, and 8.

Senior year, third term, lectures and recitations three hours per week, Civil Engineering Course only.

12. *River and Harbor Improvements.*—Reviews the control of flood water, the protection of river banks, the improvement of navigation, and the protection and improvement of harbors.

Prerequisites: Courses 4 and 8.

Senior year, third term, lectures and recitations two hours per week, Civil Engineering Course only.

13. *Frame Structures.*—Designed alike for students in Mining and Civil Engineering; treats of general methods of determining stresses in such structures as single-span bridges, roof-trusses, towers, derricks, and of the design of individual members, as posts, beams, and rods to carry specified stresses.

Prerequisites: Mechanics of Materials and Course 15.

Senior year, first term, two hours per week, Mining Engineering Course and Civil Engineering Course.

14. *Bridges (Higher Structures).*—For students in Civil Engineering only and introduces the study of arches and cantilever, swing and suspension bridges.

Prerequisite: Course 13.

Senior year, second term, five hours per week.

15. *Drawing, Graphics, and Designing.*—Students in Civil Engineering are required to complete a topographic map during the Junior year. This is followed by an exercise in the elementary problems of graphic statics as applied to single-span bridges and roofs and to masonry structures.

Prerequisite: Mechanics of Engineering.

Junior year, second term, four afternoons per week, Civil Engineering Courses; Junior year, third term, two afternoons per week, Mining Engineering Course.

16. *Engineering Designs.*—A practical course in the design of steel bridges, concrete steel structures. water supplies, and sewage systems.

Prerequisite: Course 15.

Senior year, first and second terms, three afternoons per week, Civil Engineering Course only.

17. *Special Investigations (Thesis).*—In the third term of the Senior year all graduating students give two afternoons per week to original investigation in some subject which they select, with the approval of the Faculty.

18. *Compressed Air.*—Covers the laws governing the

compression, measurement, and piping of air and the application of compressed air to the industries.

Prerequisite: Thermodynamics.

Senior year, second term, lectures and recitations two hours per week; laboratory, Senior year, second term, one afternoon per week, Mining Engineering and Civil Engineering Courses.

19. *Astronomy.*—A course in general astronomy is given for students in Civil Engineering.

Prerequisites: Courses 1c and 1d.

Junior year, third term, two hours per week.

20. *Hydraulic Motors and Pumps.*—Problems on hydraulic motors and dynamic pumps.

Prerequisite: Course 8.

Senior year, third term, one hour per week, Mining Engineering and Civil Engineering Courses.

MINING ENGINEERING.

DIRECTOR YOUNG AND PROFESSOR FORBES.

The School of Mines and Metallurgy offers a regular four-year course in Mining Engineering. At the beginning of the Senior year three options are offered in place of the Senior course of study in the regular Mining Engineering Course.

Equipment.

The surveying equipment already referred to in Civil Engineering is used for mine surveying. The School of Mines has several thousand drawings and blue-prints of mining machinery and mine plants which are used in connection with work in mining and mine management. There are also in the Library a large number of lantern slides and photographs illustrating mining practice in the United States.

The laboratories contain air-compressors, pumps, rock-drills, special drill-steel, and models of mine timbering, which are used for demonstration and experimental work.

Courses.

1. *Elementary Mining.*—This short course outlines the principles on which the science of Mining Engineering is founded, and is designed to introduce the student to fundamentals which will enable him to appreciate the applications of the other studies of the Freshman and Sophomore years.

Prerequisites: Entrance requirements.

Freshman year, first term, two hours per week.

2. *Mining.*—This course includes lectures on prospecting, drilling, blasting, boring, tunneling, shaft sinking, and mining methods. The various tools and appliances used in these operations are described. A review of methods of mine timbering is included in the course.

Prerequisite: Course 1.

Sophomore year, first term, two hours per week, Mining Engineering Course.

The same course is given in the summer school.

3. *Mining.*—This course is a continuation of Course 3 and includes lectures in mine haulage, hoisting, mine drainage, mine ventilation, lighting, accidents, and hygiene.

Prerequisite: Course 2.

Sophomore year, second term, two hours per week, Mining Engineering Course.

4. *Mine Surveying.*—The theory and the practice of the surveying of mineral lands and mines are presented by lectures. Many problems are introduced and the student is trained in various calculations, including the reduction of notes of underground surveys requiring the auxiliary telescope, volumes of stopes, mineral acreage, intersections of veins, underground connections, and general problems in the determination of the location of mine openings. A mine surveying trip to the Joplin district is a required part of the work of the Junior year.

Prerequisite: Plane Surveying.

Sophomore year, third term, three hours per week, Mining Engineering Course.

5. *Junior Trip.*—At the end of the school year the members of the Junior class make a three weeks' trip to the mining districts of southeast and southwest Missouri. The purpose of the trip is to give an opportunity for the study of the methods of mining and the concentration of ores in the districts visited, together with work in mine surveying and geology.

A complete report of the work of the trip is required.

Prerequisite: General Geology, Elements of Ore Dressing, Mining Courses 1, 2, 3, and 4.

6. *Mining Law and Contracts.*—The general principles of mining law are reviewed with discussions of legal decisions in representative cases. The students are given the general principles governing the making of contracts, together with discussions of contracts typical of various mining districts.

Senior year, first term, two hours per week, Mining Engineering, Civil Engineering, and Metallurgy Courses.

7. *Mine Management.*—This course is planned to give the student an idea of the principles of management of mining enterprises, and reviews methods of mine organization, mine accounting, and presents economic problems in connection with mine management. The practice of mine examination and mine reporting is reviewed.

Prerequisites: Courses 1 to 6.

Senior year, third term, two hours per week, Mining Engineering Course.

Texts: Rickard, *Economics of Mining.*
Rickard, *Ore Sampling.*

8. *Mining Machinery Laboratory.*—Prior to undertaking laboratory work on special mining machinery, the student is given a thorough training in the machine shop. This work includes chipping to a line, filing to a dimension, and scraping to a surface plate; the principles and uses of the drill-press, planer, lathe, shaper, and milling machine. In this work use is made of the vernier micrometer, thread micrometer, and gear-tooth caliper. The degree of accuracy thus acquired enables the student to use eye and hand in unison and is of lasting benefit in teaching exactness in statement and measurement.

Special attention is given to various types of mining machinery and to the study of steel and other materials which enter into the construction of such machinery.

Prerequisites: Courses 2 and 3.

Laboratory work, Senior year, first term, one afternoon per week; second term, three afternoons per week, Mining Machinery Option.

9. *Mining Machinery.*—This course includes an outline of the various types of machinery used in mining operations and is planned to familiarize the student with the best designs of machinery in order that he may be able to select the proper machine for the particular condition; that he may know when each machine operates efficiently, and know how to keep the machine in a first-class condition.

The machinery studied includes rock-drills, coal-cutters, mine-hoists, mine-pumps, mine-locomotives, wire-rope haulage systems, mine-fans, excavating machinery, and safety appliances.

Prerequisites: Courses 2, 3, and 7.

Senior year, second term, four hours per week; third term, five hours per week, Mining Machinery Option.

10. *Mining Machinery Problems.*—This course is a continuation of Course 8, and includes advanced work in the machine shop in connection with mining machinery. The methods of testing various machines under working conditions are presented and whenever possible such tests are carefully carried out underground.

Prerequisites: Courses 8 and 9.

Senior year, third term, two afternoons per week, Mining Machinery Option.

Graduate Courses.

11. *Mine Examination and Reports.*—This course reviews the various types of reports which a mining engineer may be required to make and emphasizes particularly the form and style of the report. Reports prepared by representative engineers are studied. Methods of mine sampling and mine valuation are reviewed. Each student prepares several reports and studies the best means of illustrating and presenting technical reports.

Prerequisites: Courses 6 and 7.

Graduate Course, second term, three hours a week.

12. *Mine Plant.*—The complete mine plant is studied. Both metal and coal mine equipment are considered and each student is assigned, for special study, one of the plants visited on the Junior trip. The course reviews the design and construction of mine buildings, ore-bins, head frames, power plants, and mining machinery plants. The financial problems involved are considered in a thorough manner.

Prerequisites: Courses 2 and 3.

Graduate Course, second term, three hours a week.

13. *Mine Plant Design.*—This course supplements the lecture course in Mine Plant. Each student is required to prepare complete drawings for the equipment of a given mine. Bills of materials, specifications, and complete estimates are submitted.

Prerequisites: Frame Structures and Courses 2 and 3.

Graduate Course, second term, one afternoon a week; third term, three afternoons a week.

14. *Mining Economics.*—Various economic problems of interest to mining engineers are studied. The influence of mining in the history of America and especially in United States history is reviewed and the relation of mining to other industries is considered. The organization of the mining industry, the conservation of the mineral resources, and various problems in economics, including mining labor, wages, capital, taxation, profit-sharing, and employers' liability are presented by lectures and assigned reading.

Prerequisites: Economic Geology and Courses 6, 7, and 11.

Graduate Course, third term, two hours a week.

15. *Mining Research.*—Each student is permitted to elect a subject for special study. It is recommended that this subject shall be along a line different from the thesis. The work begun in the fall term is continued throughout the year and consists of conferences with the professor, assigned reading, and research.

Graduate Course, five hours a week throughout the year.

GEOLOGY AND MINERALOGY.

PROFESSOR GRISWOLD, ASSISTANT PROFESSOR COX,
MR. McNUTT.

Equipment.

The mineralogy laboratories are on the second floor of Norwood Hall. They are equipped with suitable tables for the examination of minerals and rocks. They contain the extensive collections of wooden and glass models and the reference and working mineral collections. The laboratory for lithology contains a representative collection of rocks for reference and a large working collection.

The geological and mineralogical equipment includes a representative collection of minerals, rocks, and fossils for class use; a large collection of cabinet specimens of minerals and ores, and of materials illustrating metallurgical processes. There have been recently added to the equipment of this department several large geological relief models, which aid materially in the work in stratigraphical structural geology.

There is also a collection of thirty-five hundred specimens, representing the mineral wealth of Missouri, consisting of coal, clays of many sorts, and building stones, and ores of lead, zinc, iron, and copper. The minerals occurring as gangue with the metalliferous deposits of the State are also well represented. There is also a complete collection of the economic minerals of Missouri and a good economic geological collection representing the world at large. This collection was a part of the Missouri Mineral Exhibit displayed at the World's Fair at Chicago. It was presented to the School of Mines and Metallurgy by the General Assembly in 1895.

In addition to the above mentioned collection, the State Board of Equalization assigned to the School the specimens, models, maps, and machinery which constituted the Missouri Mining Exhibit at the St. Louis Exposition, thus giving to the School a large amount of valuable equipment.

The Museums contain crystals and minerals from various important mining districts of the State of Missouri, the economic collections from southwest Missouri, the great geological relief map from the St. Louis Exposition, polished stone tables and other complete collections of the Missouri Building and ornamental stones from the same exposition.

A rock section machine and instruments for geological surveys are included in the equipment of this department.

Courses.

1. *Mineralogy* (*Crystallography*).—Open to all. A study of the crystal systems, illustrated by wooden and glass models and actual crystals.

Lectures, Freshman year, third term, two hours per week.

Laboratory work, Freshman year, third term, two afternoons per week.

Text: Dana, *Text-book of Mineralogy.*

2. *Mineralogy* (*Physical Properties of Minerals*).—Open to those who have completed crystallography and Freshman chemistry. The course of lectures and laboratory work which are carried on alternately. The work includes the description, study, and identification of 200 minerals, special care being given to those minerals which constitute ores (both metallic and non-metallic), gangue materials, and the principal rock-forming silicates.

Lectures, Sophomore year, first term, two hours per week.

Laboratory work, Sophomore year, first and second terms, two afternoons per week.

The work of the first two terms is repeated during the summer school.

3. *Lithology.*—Open to those who are taking mineralogy. The course consists of the study of igneous, sedimentary and metamorphic rocks by the aid of a pocket lens. The well crystallized igneous rocks are studied with reference to their texture, mineral composition, and acidity as indicated by their general appearance; while those which are fine grained or glassy, together with the sedimentary and metamorphic rocks, are studied with respect to their general appearance and struc-

ture. This course is adequate for all general field determinations.

Lectures, Sophomore year, second term, two hours per week.

Laboratory work, Sophomore year, second term, two afternoons per week.

Text: Kemp, *Handbook on Rocks.*

4. *Petrography (Mining Geology Option Course).*—Open to those who have completed mineralogy and lithology. The first term is devoted to the study of optics as applied to the examination of minerals by the polarizing microscope and the identification of the rock-forming minerals. The second term includes the study of rock nomenclature and the grinding of rock and mineral thin sections. The third term consists of the complete description of rocks from both hand specimen and thin section, and a study of rock alterations.

Lectures, Senior year, first, second, and third terms, three hours per week.

Laboratory work, Senior year, first term, three afternoons per week; second and third terms, two afternoons per week.

Texts: Luquer, *Minerals in Rock Sections.*
Kemp, *Handbook of Rocks.*
Iddings, *Rock Minerals.*
Winchell, *Elements of Optical Mineralogy.*

5. *General Geology.*—This is a lecture course involving the principles of general and economic geology. It discusses the evolution of the earth, its present condition, and the processes which have modified its crust and surface.

Junior year, first term, five hours per week; second term, three hours per week; third term, five hours per week.

Prerequisites: Courses 2 and 3.

Text: Scott, *An Introduction to General Geology.*

6. *General Geology Laboratory—Structural Geology.*—The student has work upon geological models, maps, and

photographs, with the view to interpreting geological structures and land surface forms.

Prerequisite: General Geology, first term.

Junior year, second term, one afternoon per week.

Field Work.—The student visits various localities near Rolla with the instructor and has the various types of geology explained; then he is assigned an area to map geologically.

Junior year, third term, two afternoons per week.

The course is supplemented by the summer field excursions to southeast Missouri or Colorado.

7. *Economic Geology.*—This is a series of lectures dealing with the occurrence, origin, and distribution of ores, clays, building stones, gems, water supply, and other products of economic value from the different geological formations. The characteristics and genesis of ore deposits are carefully considered. The members of this class visit local points of economic importance near Rolla, studying iron, lead, coal, clay, and building-stone, besides making an excursion to the zinc-lead district of Joplin.

Prerequisites: Courses 5 and 6.

Senior year, first and second terms, three hours per week; third term, five hours per week.

Text: Ries, *Economic Geology of the United States.*

8. *Geology of the United States.*—This lecture course considers the various geologic and physiographic provinces of the United States and adjacent areas in the relation to geological development and economic interest.

Prerequisite: Course 5.

Optional for Seniors, first term, three hours per week.

9. *Geological Conference.*—The conference consists of a discussion by the students and instructors of geological literature or problems associated with extra reading or with the laboratory work of the term.

Prerequisite: Course 5.

Optional for Seniors, second term, two hours per week.

10. *Structural Geology.*—Open to those who have completed general geology. The course consists of a study of rock deformations, the evidence of and the resulting structures, and includes a review of the theories of the origin of the earth, a discussion of the zones of rock fracture, rock flowage, and combined rock fracture and flowage; and a classification and discussion of cleavage, joints, faults, folds, autoclastic rocks, conglomerates and pseudo-conglomerates, and mountain building forces, together with the horizontal and vertical depths affected, with applications to special districts.

Lectures, three hours a week, third term.

11. *Senior Geological Laboratory.*—(a) One afternoon per week is given to mapping a local area, the resulting map to be accompanied by a geological report.

Prerequisites: Courses 5 and 6.

Senior year, first term, Mining Engineering Course.

(b) This includes the drawing of maps and sections; or experimental work, planned with reference to the Geological Conference (Course 9) and to Structural Geology (Course 10).

Senior year, second term, two afternoons per week.

(c) Excursions are made to various localities of economic interest within easy reach of Rolla, and also to the Joplin district.

Senior year, third term, one afternoon per week, Mining Engineering Course; optional for Seniors, third term, one afternoon per week.

METALLURGY AND ORE DRESSING.

PROFESSOR COPELAND, MR. DUDLEY, MR. MANN, MR. HARLAN.

Equipment.

The assay laboratory has a floor space of forty-eight hundred square feet. In the main room are twenty coal-fired double-muffle assay furnaces, twelve gasoline-fired muffle furnaces, and ten coke-fired furnaces. Desks containing lockers, pulp balances, and fluxes are arranged close to the furnaces.

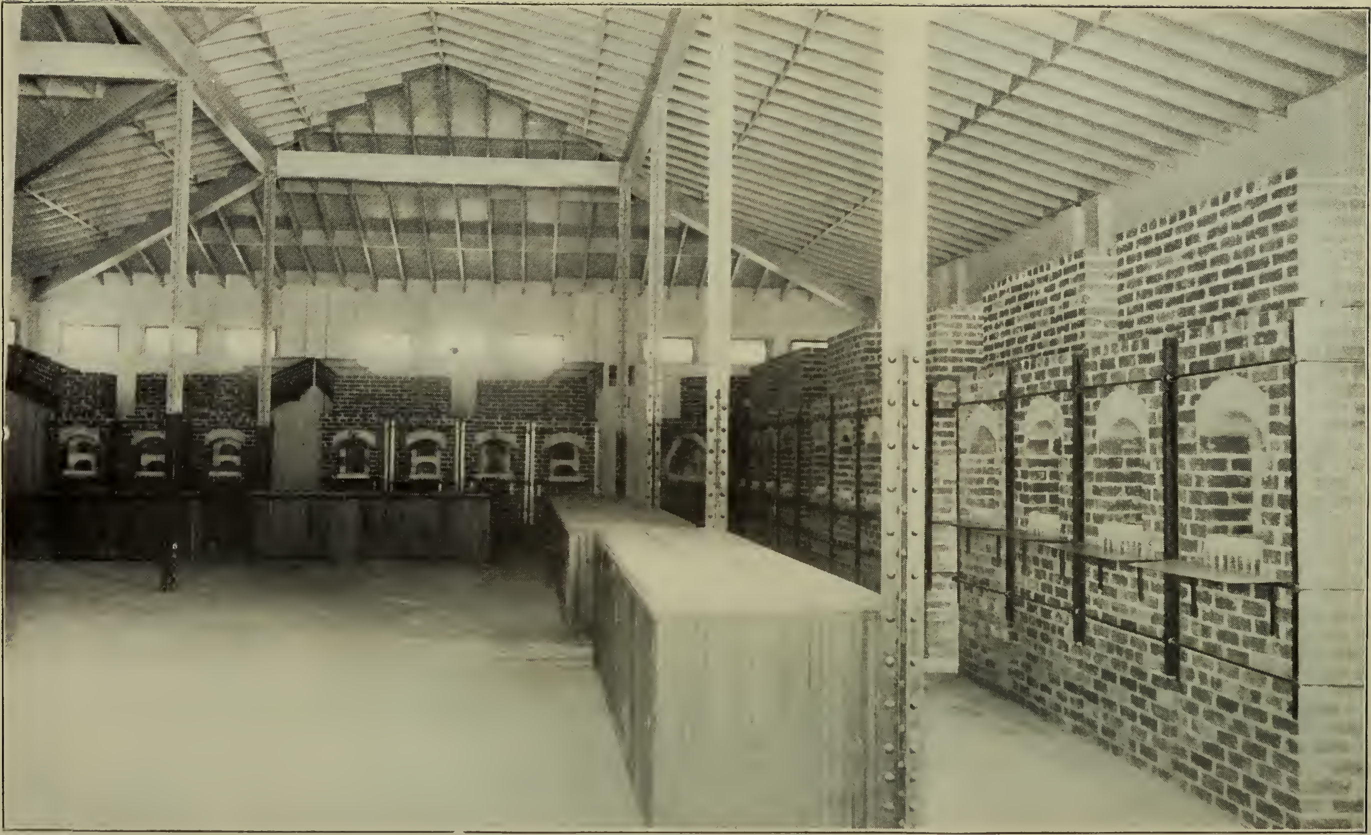
A room 16 by 16 feet, separated from the furnace laboratory by glass partitions, is used for parting. There are in this room the necessary hot plates, acid jars, and annealing muffles. The desks in this laboratory are topped with white tiling.

The balance room is 20 by 20 feet and is lighted only from the north. It is easily kept at constant temperature. There are eleven balances suitable for weighing gold. A number of these balances have the multiple-rider attachment.

For chemical work in connection with metallurgy, there is a well-lighted room having fifty-six lockers and fifty-six desks. Each desk is provided with gas, compressed air, and water. There is in the room ample hood space; in fact, the laboratory has everything necessary for general chemical work.

There is in the main furnace room a circular water-jacket blast furnace, 20 inches in diameter at the tuyeres, and 7-foot smelting column. This furnace is used for lead and copper smelting. For roasting ores a hand reverberatory furnace, with a hearth 4½ by 9 feet, is provided. This laboratory contains also an experimental pot roaster, an experimental zinc distilling furnace, 3 Le Chatlier thermo-electric pyrometers, a Wänner optical pyrometer, a cyanide testing plant containing tanks capable of holding 100 pounds of ore, a laboratory tube-mill, and laboratory amalgamating pans.

A stock room, containing chemicals, clay goods, glassware, and other supplies, serves all the laboratories. The ore-sample room is especially well equipped. It contains more than 1,000 samples of ore of varied classes. Each sample is stored away in paper sacks, all ready for issuing to the students. Each



COAL-FIRED ASSAY FURNACES

sample has been prepared and carefully assayed. Enough of each lot of ore has been prepared to give 200 to 300 samples of the same lot. The sample room, therefore, contains more than 1,000 different samples of ore, each sample being divided into 200 or more smaller samples, each of the smaller samples being ready for immediate issue.

Throughout the metallurgical and ore-dressing laboratories care has been taken that each furnace, each piece of apparatus, should be so arranged as to be fitted best for that testing work which must be so great a part of the students' work. In all the laboratory work, in addition to demonstrating the theories and principles explained in the class room, the attempt is made to give the man ability to do a day's work and to teach him to use both his head and his hands.

The main floor of the new ore-dressing laboratory occupies a space of forty-eight hundred square feet and a mezzanine floor provides an additional space of thirteen hundred square feet. The equipment of the laboratory is as follows: The crushing and sampling department contains a gyratory breaker, a Dodge breaker, a pair of 9-in. by 12-in. rolls, two plane shaking screens, two Vezin samplers, two bucket elevators, three belt conveyors, and six ore storage bins, each equipped with an automatic feeder. For fine crushing and amalgamation tests are provided a three-stamp mill, with amalgamated plates, and a 3½-ft. Huntington mill.

Ores are prepared for concentration by the following series of machines: Three trommel screens, a duplex Callow traveling belt screen, a Richards pulsator classifier, a four-spigot Richards vortex classifier, a three-spigot cone classifier, a small Tamarack classifier, and four Callow settling cones.

Methods of concentrating coarsely-crushed ores are illustrated by three five-cell differential motion Harz jigs, a Richards pulsator jig, and a small model of the Hancock jig. Sands are treated on two laboratory-size Wilfley tables, one laboratory Card table, and one laboratory James table. A four-foot Frue vanner and a five-foot Sperry slimer are provided for the treatment of fine materials.

Two direct-connected motor-driven centrifugal sand pumps are used for elevating finely crushed ore to the screening and classification system.

The sample finishing room contains a small Blake crusher, a disc grinder, a coffee mill, a pair of rolls, a number of bucking boards and mullers, and an electric sample dryer.

The cyanide unit contains a laboratory leaching plant with all necessary tanks, a 16-in. Hendryx clay agitator, a 14-in. Hendryx combination agitator and filter, and a six-leaf 12-in. by 12-in. filter press.

Ores suited to magnetic concentration are treated on a Knowles magnetic separator, and for the preparation of such ores a cylindrical dryer and roaster, together with a plane impact screen for dry sizing, is provided.

Throughout the mill, wherever possible, the practice of driving each machine with an individual motor has been followed.

Courses.

It is recognized that a school cannot give students, in the brief time at its disposal, that skill which comes from long practice, but it is the aim to give such training in the fundamental principles and their application, that students may become useful immediately on their entrance into the actual practice of their chosen profession. All metallurgical courses are accompanied by graded metallurgical problems.

An important feature of the instruction is experimental investigation in the metallurgical treatment of various ores.

1. *Fire Assaying.*—This work includes the assay, by scorification and crucible methods, of ores from the various mining districts of the United States. Copper ores, copper mattes, and copper bullions are assayed by fire and by the combination method. Lead ores and furnace products are assayed for lead and for gold and silver. Assays of cyanide solutions, of zinc-box residues, of silver bullion, of gold bullion, of lead bullion, and of silver-mill precipitate, are included in this course. During the course the student has practice with coal furnaces, coke furnaces, and gasoline furnaces. Besides doing the ordinary

work of assaying, the student studies the losses occurring. He learns the effects of different schemes of firing the furnaces by making analyses of the flue gases and by pyrometric measurements. The laboratory is so aranged that even with large classes a student is not hampered by other students and he learns to handle a large amount of work with the best utilization of his time.

The laboratory course is supplemented by lectures.

The same course is given in the summer school.

Prerequisites: General Chemistry and Laboratory. To be preceded or accompanied by Mineralogy.

Text: Lodge, *Notes on Assaying.*
Fulton, *Assaying.*

2. *General Metallurgy and Metallurgy of Iron.*—This course begins with general principles, including properties of metals and alloys, fuels, fluxes, calculation of charges, general study and classification of furnaces, followed by a study of processes employed for the production of cast iron, wrought iron and steel.

Prerequisites: Qualitative Analysis, Mineralogy, and Assaying Lectures.

Junior year, second and third terms, three hours per week.

Text: Campbell, *Manufacture and Properties of Iron and Steel.*
Stoughton, *Iron and Steel.*

References: Roberts-Austin, *Introduction.*
Howe, *Metallurgy of Steel.*

3. *Metallurgy of Lead and Silver.*—The properties and uses of lead, and of its alloys and compounds, are discussed in this course. A study is made of the principles and practice of sampling and purchasing ores. The major part of the course is given to the consideration of the standard and proposed methods for winning, desilverizing, and refining lead. Great stress is laid on the principles involved, and the student is referred to the text and to current literature for the details of processes. The winning of silver by smelting, amalgamation, and leaching is studied. Especial attention is given to cyanid-

ing of silver ores. Throughout the course there is brought forward the commercial view-point as well as the views strictly technical.

Prerequisites: General Metallurgy and Qualitative Analysis.

Senior year, first term, four hours per week.

Texts: Hofman, *Metallurgy of lead.*
Collins, *Metallurgy of Silver.*

4. *Metallurgy of Copper, Nickel, Mercury, Tin, Antimony.*—The metallurgy of copper is the principal part of the course. The lectures deal with the properties and uses of the copper and copper products and with the principles employed in the winning and refining of copper. Inasmuch as the metallurgy of copper is continually changing it is necessary for the student to examine carefully the various technical journals and to note the improvements and also the varying conditions affecting the metallurgy of copper.

The metallurgy of nickel, mercury, tin, and antimony are discussed only briefly.

Prerequisites: Course 2 and Quantitative Analysis.

Senior year, second term, four hours per week.

Text: Peters, *Principles of Copper Smelting.*

5. *Metallurgy of Gold and Zinc.*—The course of the metallurgy of gold considers the extraction of gold by the standard methods. Especial attention is given to cyaniding. The rapid advances in cyanide practice are discussed in the class room, and laboratory experiments on debated points are encouraged.

The course in the metallurgy of zinc includes lectures on the properties of zinc and its compounds, the concentration of zinc ores, and the manufacture of spelter and of zinc paints.

Prerequisites: Course 2 and Quantitative Analysis.

Senior year, third term, two hours per week.

Texts: Rose, *Metallurgy of Gold.*
Ingalls, *Metallurgy of Zinc.*

6. *Constitution of Alloys.*—These lectures deal with the

theoretical and practical considerations that influence the structure and properties of alloys of different types.

Prerequisite: Course 2.

Senior year, first term, two hours per week, Metallurgy Course.

7. *Electro-Metallurgy.*—Lectures are given covering the electro-metallurgical processes that are in use. Efficiency and engineering calculations based on these processes are given.

Prerequisites: General Physics, Electro-Chemistry, Physical Chemistry, and Course 2.

Senior year, first term, two hours per week, Metallurgy Course.

8. *Metallurgical Organization.*—The course briefly takes up the principles of organization and the duties of officers and accounting force of a metallurgy plant. The outline shows the extent of the course. Organization of companies and working forces, management, superintendence, skilled and unskilled labor. Then, following this, the constitution of capital, stocks, bonds, dividends, and profits.

Prerequisite: Course 3.

Senior year, second term, three hours per week, Metallurgy Course.

Text: Conyngton, *Corporate Management.*

9. *Metallurgical Problems.*—These problems aim to cover the common ones that the metallurgist meets in practice.

To accompany Courses 3 and 5.

Senior year, first and third terms, one hour per week, Metallurgy Course.

Text: Richards, *Metallurgical Problems.*

10. *Memoirs.*—The student in the Metallurgy Course is required to do a considerable amount of technical reading in German and English. Carefully prepared abstracts of valuable current articles are presented and read by the students themselves. These articles are chosen by reason of having special value along chemical or metallurgical lines.

Prerequisite: Course 4.

Reports, Senior year, first term, one hour per week, Metallurgy Course.

11. *Metallurgical Laboratory.*—This course aims to familiarize the student with the use of calorimeters and pyrometers and their calibration. Some insight is given into the ordinary methods of metallurgical investigation, and the methods of measurement which a metallurgist should know how to conduct.

Prerequisites: Courses 1 and 2.

Junior year, third term, one afternoon per week, Metallurgy Course.

Text: Howe, *Laboratory Notes.*

12. *Metallurgy Conference.*—This work is of great value to the student and aids him materially in getting the full value of his laboratory work.

To accompany Course 13.

Senior year, second term, one hour per week.

13. *Metallurgical Laboratory.*—This course covers the testing of ores for process of treatment. Ores are tested by cyaniding, chlorination, amalgamation, lixivation, concentration, and by combination methods. With aid of smelter schedules, the smelting costs are calculated and the net dollars and cents returns are balanced against the best results by any method, or combination of methods, worked out in the laboratory. The endeavor is made, not only to teach metallurgical principles in the laboratory, but also to bring home to the student the great effect which freight rates and other factors might have on the treatment which an ore should receive. Experiments are made in the reverberatory and "pot" roasting of ores, and on blast-furnace smelting of ores.

Furnace heat-equations are made by each student from data collected by himself.

The same course is given in the summer school.

Prerequisites: Courses 1 and 3.

Senior year, second term, one afternoon per week.

Text: Howe, *Laboratory Notes.*

14. *Metallography.*—This is a study of the micro-structure of iron and steel and of the effects of heat treatment.

Prerequisites: Courses 2 and 6.

Senior year, second term, one afternoon per week, Mining Engineering and Metallurgy Courses.

15. *Metallurgical Problems.*—This course has reference to the designing and proportioning of various types of furnaces for special duties and conditions. It necessitates a clear conception of metallurgical principles.

The alternative, electro-metallurgical problems, will cover the design and estimates for a copper or copper-nickel refinery.

Prerequisite: Course 4.

16. *Electro-Metallurgy Laboratory.*—This course gives a study of the principles of electro-metallurgy from the standpoint of experiments actually performed. Tests are made on the electrolytic refining of copper and of lead bullion. Experiments are performed and calculations as to efficiency are made on electric smelting.

Prerequisites: Electro-Chemistry Lectures and Laboratory and Physical Chemistry Lectures and Laboratory. To accompany Course 7.

Senior year, first term, two afternoons per week, Metallurgy Course.

17. *Metallurgy Plant.*—The arrangements of various metallurgical works are studied. The advantages and disadvantages of different equipments are given. Throughout the entire course stress is laid on the financial problems.

Prerequisite: Course 5. To accompany Course 18.

Graduate course, second term, three hours per week.

18. *Metallurgy Plant Design.*—This is a drafting-room course, and the student is given problems to solve in detail, covering a part of the class room discussions. Each student is required to submit complete drawings, specifications, and estimations of cost.

Prerequisite: Mechanical Drawing. To accompany Course 17.

Graduate course, second term, three hours a week; third term, nine hours a week.

19. *Cyaniding.*—This course teaches the principles and practice of cyaniding. The student keeps up with the progress in the art. Attention is given in all the work to the cost of operation and to the schemes used and proposed for lessening the cost. A detailed study is made of the types of filter presses, crushing machinery, and other devices used in cyanide mills. Cyaniding is compared with other possible methods of treatment.

Prerequisite: Quantitative Analysis. To accompany Course 20.

Graduate course, first and second terms, three hours a week.

20. *Cyanide Laboratory.*—The student in this course has an opportunity to test in the laboratory the methods discussed in the class room. The work is not routine, but the experiments are arranged to bring out a point under discussion or to solve, if possible, the problems occurring at the time in the class room.

Prerequisite: Course 1. To accompany Course 19.

Graduate course, first and second terms, six hours a week.

21. *Ore Supply.*—This course is intended to bring out the important subject of ore, flux, and fuel supplies. The subject is studied from a combined commercial and technical standpoint. The problems of valuing fluxes and fuels, of mixing ores so that the mixture shall command the lowest treatment rate, and of preparing, from the reduction works standpoint, treatment charges for different classes of ores, are studied.

Prerequisite: Course 5.

Graduate course, third term, three hours a week.

22. *Metallurgical Research.*—Each graduate student elects a subject for special study. It is recommended that the work

ORE DRESSING BUILDING

be along a different line from the subject chosen for thesis. The course consists principally of assigned reading, together with conferences with the professor on the matter read. The laboratories are always open for the solving of any problem that may arise.

Prerequisite: Course 5.

Graduate course, five hours a week throughout the year.

23. *Elements of Ore Dressing.*—In this course the principles of all common ore-dressing processes are briefly discussed. The various machines used for crushing, classification, and concentration of ores are described. Especial attention is given to those processes and mill schemes which the student has opportunity to see while on the Junior trip.

Prerequisite: Elementary Mechanics and Mineralogy.

Junior year, third term, three hours per week.
Text: Richards, *Text-Book of Ore Dressing.*

24. *Ore Dressing.*—In this course the principles of mechanical ore treatment are discussed in detail. The construction and theory of machines are presented in lectures, supplemented by a full equipment of models, which show the design of all common ore-dressing appliances.

The latter part of the course deals with the management of mills and with the adaptation of processes to the successful treatment of various ores.

Prerequisite: Course 23.

Senior year, four hours per week, throughout the year.
Text: Richards, *Text-Book of Ore Dressing.*

25. *Ore Dressing Memoirs.*—The student is required to do considerable reading and to prepare abstracts of articles appearing in the current technical literature. Articles of special interest in ore dressing are assigned for discussion at the weekly conference.

To accompany Course 24.

Conference, Senior year, third term, one hour per week.

26. *Ore Dressing Laboratory.*—The student becomes familiar with the operation and care of milling machinery by actual laboratory experience. All types and classes of machines are available to illustrate principles and practice as presented in the lecture work. The laboratory is so arranged that a number of mill schemes may be utilized and processes for treating a particular ore can be determined from mill tests on large quantities of the ore.

Prerequisites: Courses 1 and 23, and Quantitative Analysis. To accompany Course 24.

Senior year, first term, two afternoons per week.

27. *Ore Dressing Laboratory.*—This course is more extensive than Course 5. Besides the regular mill practice, the student makes sizing tests upon the products of breakers and determines the quality of work done by concentrating machines under varying conditions. Each student is assigned independent experimental work involving the theoretical principles which are of importance in ore dressing.

Prerequisites: Courses 1 and 23, and Quantitative Analysis. To accompany Course 24.

Senior year, first term, three afternoons per week; third term, two afternoons per week, Metallurgy Course and Ore Dressing Option Course.

28. *Ore Dressing Problems.*—In this course advanced work is given in connection with the design of plants and machinery for the treatment of ores. The course includes the determination of a practical process for treating a given ore, and the design of a mill for utilizing this process.

Prerequisite: Course 26 and Mechanical Drawing. To accompany Course 24.

Drafting room and laboratory work, Senior year, second and third terms, one afternoon per week.

WOOD SHOP

SHOP PRACTICE AND DRAWING.

ASSISTANT PROFESSOR BOWEN, MR. BUERSTATTE.

Equipment.

The shops are thoroughly equipped with machinery and benches adapted to instruction. The wood bench work-room contains twenty double benches with separate sets of hand tools. The lathe-room is equipped with twenty Fay & Egan 12-in. swing college wood lathes and iron shears. The other machines in the lathe-room include a Fay & Egan 27-in. planer, a Fay & Egan bandsaw with 30-in. wheels, an Oliver universal saw-table, two Oliver wood trimmers, a mortise machine, jig-saw, grindstone, and other necessary tools.

For instruction in forge work there are twenty-four Buffalo Forge Company down-draft forges, power hammer, drill-press, power shears, and grinder.

The metal-working room contains:
One 20-in. by 8-ft. Reed Lathe.
One 12-in. by 6-ft. Reed Lathe.
One 14-in. by 6 ft. Hendey Lathe.
One 14-in. by 6-ft. American Lathe.
One No. 2A Brown & Sharpe Universal Milling Machine.
One Hendey 15-in. Pillar Shaper.
One Dwight Sensitive Drill.
One Barnes 22-in. Swing Upright Drill Press.
One 24-in. Morse Double Emery Grinder.
One 24-in. by 24-in. by 6-ft. Chandler Planer.
Two Greenard Arbor Presses, No. 3½ and No. 1.
One No. 1 Burr Cold Saw.
One 3-fire Chicago Flexible Shaft Gas Furnace.

All of the above mentioned iron-working machinery is of latest design and driven by individual motors. The benches in the lathe-room have hardwood tops mounted on standard Brown & Sharpe bench legs. Twenty-four machinist vises, twelve of which have the swivel base and jaw, equip the shop for bench work.

The drawing rooms are equipped with double drawing tables and will accommodate two hundred and forty students working in two sections.

Courses.

1. *Wood Work.*—The work in this course begins with simple exercises in planing and marking with the gauge and knife. It continues until the pupil has become thoroughly familiar with the use of the plane, bevel, square, gauge, and knife. He is then given graded exercises covering rip and cross-cut sawing and sawing to a "fit." Following this comes work at joints designed to show the different methods of construction, glue joints, doweling, dove-tails, and braces. This work is supplemented by talks on the tools and work in hand, and each student is required to pass a written examination on notes covering the classification and use of hand tools and accessories.

This preliminary work is followed by the construction of a drawing desk of our own design, which is a very rigid and substantial individual desk. It is designed for two sections, each student having a separate drawer and locker for instruments and drawing board, where they are free from disturbance and dust. Following the desk comes wood turning, which is designed to familiarize the student with the use of the lathe. He is given graded exercises, beginning with a plane cylinder, including curves of various kinds and sizes and concluding with face-plate work in rings, balls, goblets, and vases. On all the preliminary work students are required to use the tools in such a way as to make the use of sandpaper unnecessary.

A final part of this course is cabinet-making, designed to give the student work on the planer, universal saw-table, wood-trimmer, scroll-saw, and mortise-machine. After becoming familiar with the different machines, pattern-making is begun, the purpose of this work being to teach the student to make representative types of patterns from which castings may be made. The principles of the shrink rule are explained, and drawings, such as are used in manufacturing plants, are made in order to teach the use of the finish marks, core boxes, and all conventional signs.

All work is done from drawings.

Prerequisites: Entrance requirements.

Freshman year, first and second terms, two afternoons per week.

2. *Forge Work.**—This course begins with simple exercises in drawing, upsetting, bending, twisting, punching, and welding. The work gradually becomes more difficult, such as making eye-bolts, chains, and tongs. Tool-making is then begun by making screw-drivers, hammers, chisels, and a complete set of lathe tools, which will be used later in the machine shop. This work is fully illustrated by drawings and lectures on the subject, covering the properties of the different grades of iron and steel. The instructors make the student familiar with the best grade of steel to be used for any required purpose, and the correct shape and temper necessary for the best work in cutting iron, steel, brass, and stone. The final and most important part of this work is the testing of rock-drills of different makes, care being taken to preserve the results of the tests on different grades of steel used.

Prerequisite: Course 1.

Sophomore year, two afternoons per week during the entire year.

3. *Metal Work.*—This course begins with chipping to a line, filing to a dimension, and scraping to a surface plate. Machine operation is then begun; the principles and uses of the drill-press, lathe, planer, shaper, and milling machine are taught by lectures followed by practical work at each machine. After a reasonable time, skill is attained in operating the various machines through a course of graded exercises. Students are required to build complete machines designed by upper classmen or by the instructor. In this work use is made

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*Students may elect three terms in machine drawing instead of three terms in forge work.

of the vernier micrometer, thread-micrometer, and gear-tooth caliper. The degree of accuracy thus acquired enables the student to use eye and hand in unison, and is a lasting benefit in teaching exactness in statement and measurement.

This is a part of the course in Mining Machinery Laboratory, described as Course 12 in Mining Engineering.

Prerequisite: Course 2 or 5.

4. *Mechanical Drawing.*—The student is first given practice in geometrical construction until he is familiar with the nature, care and use of drafting instruments. Then, after carefully studying the principles of orthographic projection, intersection, and development, he is thoroughly drilled in free-hand lettering. The course is completed with one term of machine drawing. In this the student is required to make sketches, detail and assembly drawings of machines, and is taught the principles of elementary machine design.

Prerequisites: Entrance requirements.

Freshman year, six hours per week throughout the year.

Texts: Anthony, *Mechanical Drawing.*
Wilson, *Free-Hand Lettering; Machine Drawing.*

5. *Machine Drawing.**—This course is a continuation of the work in mechanical drawing of the Freshman year. It includes exercises covering gearing, power transmission, mechanism, and the simpler machines used in mining, ore dressing and metallurgy.

Prerequisite: Course 4.

Sophomore year, two afternoons per week throughout the year.

6. *Descriptive Geometry.*—The usual text-book works is reinforced with daily blackboard exercises in presenting the projections of familiar objects, intersections of plane and curved surfaces, sections, developments, and shades and shad-

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*Students may elect three terms' work in the forge room instead of three terms' work in machine drawing.

FORGE SHOP

ows. The afternoons in the drawing-room are spent in solving in neat form the more elaborate exercises.

Prerequisites: College Algebra and Mechanical Drawing.

Freshman year, second and third terms, two recitations per week, and three hours at the drawing board.

Text: Faunce, *Descriptive Geometry.*

ENGLISH.

Mr. Scott.

Efficiency in oral and in written expression on the part of the engineer is no longer considered among teachers in technical schools a matter of secondary importance. Efficiency in English, like that in any purely technical subject, can be acquired only by a systematic study of the principles underlying the subject, followed by long apprenticeship of practice under judicious criticism.

No credit for advanced standing in English will be given unless the work for which the credit is asked was done in the collegiate department of an accredited college or in the Junior or Senior year of a State normal school.

1. *Theme Work.*—All Freshmen are required to write, throughout the year, short, daily and long fortnightly themes. This work is carefully criticised by the teacher, corrected by the student, and returned to the critic as evidence that the student has profited by the criticisms.

Prerequisites: Entrance requirements.

2. *Rhetoric.*—Phases of this subject, too complex for high school, are studied.

Prerequisites: Entrance requirements.

Freshman year, five hours a week throughout the year.

Texts: Brewster, *Representative Essays on the Theory of Style.*
Pearson, *Principles of Composition.*
Carpenter, *Advanced Composition, and Rhetoric.*

3. *Advanced English.*—All Sophomores are required to write, each month, at least one long theme of not less than a thousand words. The forms of composition represented by these themes will be exposition and argumentation. An equal number of subjects are selected from each form and are criticised in the same manner as the Freshman themes.

The class work in Advanced English will be a critical study of present-day practical articles, which in thought and style are masterpieces. After an article is analyzed as to thought and style, the student will be required to write an original article in imitation of the one studied.

Prerequisites: Courses 1 and 2.

Text: Percival and Jelliff, *Specimens of Exposition and Argument.*

4. *General Science English.*—The major part of the course will consist of the theoretical study of the forms of composition known as exposition and argumentation, with the frequent writing of short and long themes, and occasional oral debates. The study of English and American literature will receive some attention, but the work will be mainly to illustrate ideal exposition and argumentation from the point of view of the present day practical man. A part of one term will be given to the criticism of the language of technical literature as found in scientific journals.

Prerequisites: Courses 1 and 2.

Sophomore year, five hours a week throughout the year, General Science Course.

Texts: Percival and Jelliff, *Specimens of Exposition and Argument.*
Rickard, *Technical Writing.*

MODERN LANGUAGES.

MR. WILKINS.

The great quantity and worth of the technical literature in the French and German languages, added to their value as elements of liberal culture, make at least a reading knowledge of them practically a necessary part of an engineer's education.

The instruction in each language is designed to present the grammatical structure and the pronunciation of the tongue—to give some acquaintance with the masterpieces of its literature, and to confer such facility in translation as will enable the student to read with ease the language in both its literary and its scientific uses.

German (*Elementary*).—For such students who elect German as the foreign language in their course, and who have not had at least one year of high school German.

Prerequisites: Entrance requirements.

Freshman year, second and third terms, four hours per week.

German (*Scientific*).

Prerequisite: Elementary German.

Text: Dippold, *Scientific German Reader* and current scientific journals and magazines.

Sophomore year, five hours per week throughout the year.

French (*Scientific*).—Students who have not had Elementary French will not be permitted to elect this language.

Prerequisite: Elementary French.

Text: Herdler, *Scientific French Reader* and current scientific journals and magazines.

Sophomore year, five hours per week throughout the year.

Spanish.—The growing demand for mining engineers and metallurgists in South and Central America, in Mexico and in the Philippines, where a knowledge of Spanish is almost an essential qualification, has been met by the establishment of a course in this language in the School of Mines. The natural or conversational method is followed exclusively. The object is to give the student facility in the every-day speech of the people. With the consent of the Faculty, students may elect Spanish as the required modern language.

Prerequisite: Rhetoric.

Text: Hill and Ford, *Spanish Grammar.*
Umphrey's *Spanish Prose Composition* (Third Term).

GENERAL INFORMATION.

Terms and Vacation.

The college year, consisting of thirty-six weeks, exclusive of the Christmas holidays, is divided into three terms. The first term begins September 6 and ends December 22; the second term begins January 3 and ends March 10; the third terms begins March 13 and ends May 26.

The Christmas holidays intervene between the first and second terms, but there is no interruption of work between the second and third terms. Thanksgiving Day and Washington's Birthday are observed as single holidays.

Excursions.*

The State of Missouri occupies an important place in the mining industry and many opportunities are offered students at the School of Mines and Metallurgy for keeping closely in touch with the mining industry of Missouri and adjoining States. There have been many important developments during the last few years in methods of mining, dressing, and smelting lead and zinc ores. The lead district of southeast Missouri and the zinc district of southwest Missouri offer numerous examples of up-to-date practice in mining and metallurgical engineering. The aggregate tonnage capacity of the concentrating plants of Missouri is greater than that of any other State of the Union. The importance of modern methods of ore dressing is everywhere recognized and the facilities offered by the School of Mines for investigation in ore dressing, together with the practice in concentrating plants which are visited, places the School of Mines and Metallurgy in the foremost rank in this important branch of mine engineering.

Frequent trips and excursions give the student an opportunity to study mining, ore dressing, and metallurgical methods. Field work in metal mine surveying is carried on in suitable mines conveniently located in southeast and southwest Missouri. The practice in coal mine surveying is usually

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*See also page 33.

VIEW ON JACKLING FIELD

given in one of the northern Missouri coal mines or in the Illinois field.

The Junior class visits southeast Missouri to study the geology, methods of mining, and the milling of great disseminated lead deposits. The geological work of the Junior trip is especially valuable because of the variety of work introduced. The class has an opportunity to study several varieties of pre-Cambrian rocks of igneous and other origin. Differentiation in magma and intrusions can be seen. The pre-Cambrian topography is discernable in relation to the contact plane between the pre-Cambrian and the Cambrian. Evidence of superimposed drainage is offered. Iron ores of Shepard Mountain, Pilot Knob, and Iron Mountain give interesting study in the distribution and origin of ores. The general relation of the lead ores of the Paleozoic is also studied. The weathering of various kinds of rock in conjunction with jointing and stratification is well illustrated. The Carboniferous basin about St. Louis is given a brief examination. The student should be provided with note-book, compass, clinometer, hammer, and magnifying glass. The observation work of the day is supplemented by evening conferences.

The concentrating plants of southeast Missouri are large and modern, containing crushers, rolls, elevating machinery, Wilfley tables, Frue vanners, jigs, and sundry other machines. The mining plants are thoroughly modern and include steam and electric hoists, modern steel head-frames, compressed air and electric haulage, extensive pumping-plants, and numerous diamond-drill prospecting equipments.

In southwest Missouri the geology, mining, and milling of the shallow deposits as well as of "sheet" ground are studied by the Seniors. Opportunity is given to inspect and study the various types of equipment and methods as adapted to shallow and deeper mining. Many new concentrating plants have been erected and are strictly modern in design and equipment. The application of electric power to mining and milling is well illustrated in this district. Short trips are made to neighboring camps in southeastern Kansas.

During the summer of 1909, a section of the Junior class made a trip to Colorado and Utah, visiting Denver, Idaho Springs, Central City, Georgetown, Silver Plume, Montezuma, Breckenridge, Leadville, Colorado Springs, Cripple Creek, Victor, and Pueblo in Colorado, and Salt Lake City, Garfield, and Bingham in Utah. The work in mine surveying was done at Idaho Springs. Special attention was given to mining practice in the Clear Creek District, the Cripple Creek District, and Leadville and vicinity. Amalgamation was studied in the Clear Creek District; cyanidation at Colorado Springs and Victor; smelting of gold, silver, copper, and lead ores at Leadville and Pueblo; iron and steel metallurgy at Pueblo; treatment of zinc ores at Leadville. Throughout the entire trip the important geological features were noted, a particular study being made of the Garden of the Gods and of the ore deposits of Leadville and of Cripple Creek.

Special attention is paid on these trips to general engineering problems, plant design, economy of operation, and organization.

During the Senior year several trips are made to the metallurgical plants in the vicinity of St. Louis. The plant of the St. Louis Blast Furnace Company illustrates blast-furnace practice. Here may be studied the blast-furnace, regenerative stoves, blowing machinery, power plant, and other appliances necessary for the production of pig iron. Open-hearth steel methods and the manufacture of steel castings is studied at the Scullin & Gallagher Works. This plant includes, in addition to the usual type of open-hearth furnace, Bessemer converters, cupolas, and gas-producers.

The metallurgy of zinc is studied at the Edgar Zinc Works at Carondelet, where the roasting of blende and distillation methods may be seen. The Federal smelter, at Alton, is visited for the study of lead smelting. At this plant the lead blast-furnace, the Huntington-Heberlein roasting system, and the Scotch ore-hearths are carefully inspected. This plant also includes an extensive bag-house. The manufacture of white-lead paint and of lead pipe is seen at the National

Lead Works. A further study of lead smelting is made at Herculaneum, where blast-furnaces are served by Savelsberg pot roasters. At the various plants enumerated, particular attention is paid to the construction of furnaces, the operation of the plant, and the general organization and design.

The manufacture of refractory materials is carefully followed from the mine to the finished product at the plant of the Laclede-Christy Company. This plant is one of the largest clay manufacturing works in the world, and a metallurgist here has a splendid opportunity to investigate refractory products and materials used in the construction of furnaces, stacks, retorts, and crucibles.

These excursions are a required part of the courses and no substitutions are allowed. Every candidate for a degree must take the prescribed excursions as scheduled.

Student Organizations.

The following chapters of college fraternities exist at the School: Gamma Chi of Sigma Nu, Beta Alpha of Kappa Alpha, Beta Chi of Kappa Sigma, Alpha Kappa of Pi Kappa Alpha, and Missouri Beta of Tau Beta Pi.

The Young Men's Christian Association was organized in the College several years ago, and is growing rapidly. It stands for the best there is in college life and brings together those who believe that college men should develop well-rounded characters, physical, mental, and spiritual. During the opening days of the college, trains are met by association members, who place thmeselves at the service of the new men, helping them to secure rooms and board and to matriculate. The Association occupies the second floor of the Mining Building, where all students are welcomed and regular meetings are held.

The School of Mines Band furnishes music for athletic and outdoor functions and maintains a splendid organization.

The School of Mines Orchestra is reputed, throughout south-central Missouri, as without equal, and furnishes music for all School entertainments, the Commencement Exercises, and gives concerts in nearby towns.

Other Student Organizations include the Glee Club, the Mandolin Club, the Mathematical Club, and the International Club.

The student body publishes a year-book called "The Rollamo." The purpose of this volume is to record the student activities and to present a review of college life at Rolla.

Athletics.

The School encourages rational athletics and has provided an instructor in physical training who has entire supervision of the physical training of students and of all intercollegiate sports. Occasional privileges are granted to athletic teams, but prolonged absences from work are not permitted.

The Jackling Field provides for baseball, football, and other games, and an ample number of tennis courts have been laid out, and are maintained in good order. Suitable dressing-rooms and shower-baths are provided in a temporary building on the athletic field. A gymnasium is provided on the second floor of Mechanical Hall. Suitable gymnasium apparatus is supplied and indoor games can be carried on during the winter months. A general athletic association exists among the students; also football and baseball teams and a tennis club.

Athletic Fee.—Each student is requested to pay a fee of Five Dollars to the Athletic Association of the School.

Expenses.

Tuition Fee.—Tuition is free to all students who are residents of Missouri. At a meeting held in October, 1908, the Board of Curators voted that "From and after September 1, 1909, non-residents of Missouri who matriculate in any Department of the University be required to pay a tuition fee of $20 per year."

Laboratory Fees.—The fees charged are as follows: A library fee of $5 per year, payable upon entrance; a laboratory fee in general chemistry to cover the cost of gas and supplies; $3 per term for all courses except Metallurgy and Special Mining, for which courses the fee is $10; a laboratory fee in qualitative analysis of $7.50 per term to cover the cost of general supplies and gas; a laboratory fee for quantitative analysis and other Senior and Junior chemical laboratory work, $1.75 per term; a fee of $2.50 per term to cover the cost of supplies for shop work; a fee of $2 per term to cover the cost of supplies in forge work; a laboratory fee of $12.50 per term to cover the cost of supplies in assaying; a laboratory fee of $3 per term to cover the cost of supplies in mineralogy; a fee of $5 per term for Senior metallurgy laboratory; a fee of $2.50 per term for mining machinery laboratory.

Contingent Deposits.—Deposits to cover the cost of extra supplies and damage to apparatus are required of the different classmen as follows: Freshmen, $10; Sophomores, Juniors, and Seniors, $15. These deposits must be renewed if at any time exhausted, and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

Living Expenses.—The expenses of many students for the entire year do not exceed $250, which will cover in a reasonable manner the fees, cost of books and stationery, board and lodging, and laundry. The cost of field excursions is not included in the above estimate.

Excursion Expenses.—The cost of field excursion will average about $35 per year.

BUREAU OF GEOLOGY AND MINES.

The Geological Survey of the State of Missouri has its headquarters at Rolla, and occupies the Rolla Building on the school campus.

BOARD OF MANAGERS.

Governor Herbert S. Hadley, Jefferson City	President
Hon. Elias S. Gatch, St. Louis	Vice-President
Professor Edwin M. Shepard, Springfield	Secretary
Hon. S. Duffield Mitchell, Carthage.	
Hon. J. H. Bovard, Kansas City.	

STAFF OF THE GEOLOGICAL SURVEY.

H. A. Buehler	State Geologist
G. W. Crane	Geologist
V. H. Hughes	Geologist
A. X. Illinski	Chemist
C. C. Baker	Chief Clerk
W. E. Morse	Janitor

Equipment and Investigations.

The Geological Survey has at the present time a library of approximately five thousand volumes and pamphlets on geological and allied subjects and a museum of seven thousand specimens of clay, coal, barite, lead and zinc ore, iron ore, and other mine and quarry products of Missouri.

The Geological Survey is organized principally to aid in the development of the mineral resources of Missouri. Information concerning these resources is gathered through observations in the field by members of the staff. Geologic and topographic maps are prepared of different parts of the State and the various formations are accurately described in accompanying reports. The relation of the geology to the ore deposits is also worked out and detailed reports published concerning such investigations.

The Department has the following reports available for distribution at the present time:

Preliminary Report	Vol. XIII.
Geology of Miller County	Vol. I., 2d series.
Quarrying Industry of Missouri	Vol. II., 2d series.
Geology of Moniteau County	Vol. III., 2d series.
Geology of the Granby Area	Vol. IV., 2d series.
Public Roads	Vol. V., 2d series.
Lime and Cement Resources of Missouri	Vol. VI., 2d series.
Geology of Morgan County	Vol. VII., 2d series.
Geology of Pike County	Vol. VIII., 2d series.
Geology of the Disseminated Lead Deposits of St. Francois and Washington Counties	Vol. IX., 2d series.

DEGREES CONFERRED 1909.

Engineer of Mines.

Lewis Alfred Delano, B. S., 1904.
Leo Joseph Foster, B. S., 1904.
Glenn Beckley Morgan, B. S., 1904.
Edwin Phelps Murray, B. S., 1908.
Jesse Herman Steinmesch, B. S., 1906.

Master of Science.

Horace Tharp Mann, B. S., 1908.

Bachelor of Science (Mine Engineering).

Hector George Sylvester Anderson.
John Warren Beard.
Enrique Cavazos.
James Crawford Compton.
George Albert Easley.
Roscoe Conkling Ham.
Victor Harmon Hughes.
Frank Richard Loveridge.
Arthur Lewis Pollard.
William Albert Baueris.
Fred Tete Boyer.
William Danels Clarke.
DeForrest Don.
William Simpson Hall.
Van Buren Hinsch.
Simon Jochamowitz.
William McElroy.
Edgar Joseph Wolf.

Bachelor of Science (Metallurgy).

Reginald Henry Brinton Butler.

Bachelor of Science (Civil Engineering).

Ernst Lorenz Chamberlain.
Pearl Frederic Michael.
Harvey Oden Garst.
Frank Xavier Nachtmann.

Bachelor of Science (General Science).

Edward Phillip Barrett.
Roy Hayward DeWaters.
Carl Winthrop Keniston.
Rowe Francis McCrae.
Aaron Max Shah.
William Newton Clark.
Victoriano Elicano.
Harry Clay Kibe.
Mark Stephen Mazany.
Earl McColloch Smith.
Albert Emory Wishon.

MECHANICAL HALL

THESES SUBMITTED IN 1909.

A Method of Obtaining Lead Concentrate from the Slime of a Lead Mill,
Lewis Alfred Delano.

General Method of Procedure in the Working Out of the Uncompaghre Valley Project, Colorado..............................Leo Joseph Foster.

The History and the Development of the Cyanide Industry,
Horace Tharp Mann.

Economic Investigation of the Lignites of the Dickinson, North Dakota, Area ....Glenn Beckley Morgan.

The Relation of the Composition of a Mineral to its Properties,
Edwin Phelps Murray.

A New Hindered-Settling Classifier..............Jesse Herman Steinmesch.

Minerals and Their Environment of Formation..............DeForrest Don.

Timbering in the Warren District, Cochise County, Arizona...Fred Tete Boyer.

Technical Analysis of Corn Products..............Roy Hayward DeWaters.

The Microstructure of Drill Steel....................Arthur Lewis Pollard.

Effect of Certain Minerals on Fire Assay of Lead,
Earl McColloch Smith and Rowe Francis McCrae.

Investigation of Hindered Settling Ratio of Galena, Sphalerite, and Pyrite as Compared with Quartz in Air,
William Danels Clark and Ralph Wilheim Watson.

The Effect of Arsenic on the Assay of Gold and Silver Ores,
Roscoe Conkling Ham.

Desulphurizing or Pot Roasting of Lead Ores.......Edward Phillip Barrett.

A Study of Some Problems in Assaying..................Aaron Max Shah.

Radiation Losses in Metallurgical Furnaces.......Frank Richard Loveridge.

A Study of the Settlement of Slimes,
James Crawford Compton and William Simpson Hall.

The Influence of Pyrite on the Oxidation of Galena,
William Newton Clark and Mark Stephen Mazany.

Geology Along the St. Louis and San Francisco Railroad from Rolla to Newburg ....Victor Harmon Hughes.

The Construction of a Smelter for the Production of Zinc-White from Western Lead-Zinc Ores,
Hector George Sylvester Anderson and Van Buren Hinsch.

The Design of a Dam and the Investigation of a Water Supply for the City of Rolla, Missouri,
Frank Xavier Nachtmann and Ernst Lorenz Chamberlain.

Design of Reinforced Concrete Water Tower and Tank,
Harvey Oden Garst and Pearl Frederic Michael.

The Volatilization and Absorption of Silver Chloride,
EDGAR JOSEPH WOLF AND VICTORIANO ELICANO.

Design and Details of Elevated Steel Water Tower..WILLIAM ALBERT BAUERIS.

A Study of the Losses of Gold During Cupellation in the Presence of Tellurium........GEORGE ALBERT EASLEY AND CARL WINTHROP KENISTON.

The Construction of the United States Macadam Road at Fort Scott, Kansas ....WILLIAM McELROY.

A Comparison of the Solvents Used in the Hydrometallurgy of Silver,
SIMON JOCHAMOWITZ AND ENRIQUE CAVAZOS.

The Cyanidation of High-Grade Gold and Silver Concentrate,
REGINALD HENRY BRINTON BUTLER AND JOHN WARREN BEARD.

STUDENTS AT THE MISSOURI SCHOOL OF MINES AND METALLURGY.

1909-1910.

GRADUATE STUDENTS.

Bartlett, Albert Babbitt*........................Cheyenne, Wyo.
B. S. in M. E., 1907, School of Mines.

Chamberlain, Harry Carleton*...................Gila Bend, Ariz.
B. S. in M. E., 1905, School of Mines.

Clary, John Henry*..............................Wallace, Idaho.
B. S. in M. E., 1905, School of Mines.

Dudley, Boyd, Jr....................................Rolla, Mo.
B. S. in G. S., 1908, School of Mines.

Hunt, Lamar Horatio*.........................Pachuca, Mexico.
B. S. in M. E., 1905, School of Mines.

Keniston, Carl Winthrop.............................Rolla, Mo.
B. S. in G. S., 1909, School of Mines.

Lintecum, Charles Lafayette*...................Telluride, Colo.
B. S. in M. E., 1905, School of Mines.

Lohman, Harry William*...................Breckenridge, Colo.
B. S. in M. E., 1904, School of Mines.

Lyman, George Edwin.........................Edwardsville, Ill.
B. S. in C. E., 1902, School of Mines.

Mann, Horace Tharp.................................Rolla, Mo.
B. S. in M. E., 1908, School of Mines;
M. S., 1909, School of Mines.

Phillips, Walter Irving*........................Cheyenne, Wyo.
B. S. in Met., 1907, School of Mines.

Richards, Walter Coffran*........................Fredonia, Ky.
B. S. in M. E., 1907, School of Mines.

Rivera, Ramon* ....Guadalajara, Mexico.
B. S. in C. E., 1906, School of Mines.

Rucker, Ray Fleming*............................Hannibal, Mo.
B. S. in M. E., 1906, School of Mines.

Seltzer, Andrew Jackson*.......................Wuchang, China.
B. S. in Met., 1907, School of Mines.

Snyder, Byron John.............................Dahlonega, Ga.
B. S. in Met., 1907, School of Mines.

Tseung, Tsik Chan*.............................Changsa, China.
B. S. in M. E., 1907, School of Mines.

Wash, Edwin Richard* ....Tombstone, Ariz.
B. S. in M. E., 1907, School of Mines.

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* In Absentia.

SENIORS.

Blake, Frank Orris, Jr	St. Louis, Mo.
Bodman, John Whittlesey	Kansas City, Mo.
Boland, Earl Frederick	Syracuse, N. Y.
Bowles, James Joseph	Lake Springs, Mo.
Branham, William Grover	Joplin, Mo.
Bunten, James	Canon City, Colo.
Burdick, Charles Adrian	Dansville, N. Y.
Caples, Russell Bigelow, Jr	Glasgow, Mo.
Clark, John Charles	Chicago, Ill.
Connelly, Harry Wade	Independence, Kan.
Detweiler, Alfred Nicks	Lebanon, Mo.
Diaz, Emilio	Santiago, Chili.
Dobbins, Walter	Champaign, Ill.
Dosenbach, Benjamin Harrison	St. Louis, Mo.
Dunn, Theodore Saunders	Waukegan, Ill.
Farrar, Monroe	Mattoon, Ill.
Flynt, Frank Le Roy	Rolla, Mo.
Forman, John Kavanaugh	McFall, Mo.
Fraser, Keith Colt	Lyndonville, N. Y.
Gregory, Clay, Jr	Joplin, Mo.
Harlan, John Dee	Moberly, Mo.
Heinz, William Frederick	Achley, Iowa.
Holmes, Oliver Wendell	Rolla, Mo.
Hynes, Dibrell Pryor	Cananea, Mexico.
Illinski, Alexis Xavier	Rolla, Mo.
Jones, William Hamilton	St. Louis, Mo.
Karte, Anton Frederick	De Soto, Mo.
Kenney, John Richardson	Chicago, Ill.
Killian, Ralph Daniel	Perryville, Mo.
Lass, Charles Abraham	Agricultural Col., Miss.
List, Elmer	Cape Girardeau, Mo.
McNutt, Vachel Harry	Monroe City, Mo.
Mackey, Robert William	Waukegan, Ill.
Minor, Harmon Edwin	Canon City, Colo.
Mook, Robert Lee	St. Louis, Mo.
Morgan, Allen Ray Dearborn	Rolla, Mo.
Murphy, Benton Franklin	Bonne Terre, Mo.
Ohnsorg, Norman Lloyd	Rolla, Mo.
Park, Albert	Rolla, Mo.
Parsons, Frederick	Rolla, Mo.
Peterson, Howard Kelsey	New Rochelle, N. Y.
Pickering, John Lyle, Jr	Springfield, Ill.
Porri, Louis Joseph	St. Louis, Mo.

Riede, Frederick Edward	Canon City, Colo.
Schmidt, Sidney Randolph	Chicago, Ill.
Schultz, John Elmer	Topeka, Kan.
Smith, Harvey Edson	St. Louis, Mo.
Smith, Van Hoose	Little Rock, Ark.
Stewart, John Sloan, Jr.	Mansfield, Ohio.
Thompson, Reuben Conrad	Sioux Falls, S. Dak.
Traughber, Charles Weaver	Centralia, Mo.
Vogt, George	Davenport, Iowa.
Wander, Ernest	Chicago, Ill.
Welsh, Harold Llewellyn	Kansas City, Mo.

JUNIORS.

Abbott, Edward Rees	Mansfield, Ohio.
Albertson, Maurice	Aurora, Mo.
Allen, Ernest James	Forrest, Ill.
Baker, Charles Cameron	Rolla. Mo.
Beach, James Keller	Dallas, Texas.
Bingham, Raymond Alexander	Watertown, Mass.
Blake, True Walter	Chicago, Ill.
Boza, Hector	Lima, Peru.
Chase, James Howard	Logansport, Ind.
Coaske, Paul E	St. Louis, Mo.
Cody, Benjamin Horace	St. Joseph, Mo.
Copeland, Robert Nathaniel	Chelsea, Mass.
Dye, Robert Emmett	Joplin, Mo.
Elmore, Carlos	Lima, Peru.
Engelmann, Edward William	St. Louis, Mo.
Flynn, Frank James	St. Joseph, Mo.
Ford, Harold Percy	St. Joseph, Mo.
Forrester, David Lawton	Oakland, Calif.
Garcia, Herman	Mexico City, Mexico.
Gilchrist, K. P	Lathrop, Mo.
Goldman, Jay Maurice	St. Louis, Mo.
Groves, Frank W	Des Moines, Iowa.
Harris, Deane Dwight	Rolla, Mo.
Hirdler, Eva Endurance	St. Louis, Mo.
James, Ivory Small	San Antonio, Texas.
Keelyn, James Lawton	Evanston, Ill.
Kurz, J. Adolph	St. Louis, Mo.
Lindau, Sam Paul	Liberty, Mo.
Lunak, Otto Allen	St. Louis, Mo.
McGoughran, James E	Rolla, Mo.
Macomber, Sumner Cooley	Des Moines, Iowa.

Maveety, Roswell Hall	Cincinnati, Ohio.
Mitchell, Robert Bruce	Walker, Mo.
Nason, Stanley	West Haven, Conn.
Owen, Harvey Skidmore	St. Louis, Mo.
Pudewa, Arthur G	Chicago, Ill.
Raj, Shiv	Lahore, India.
Randolph, Oscar Alan	Kansas City, Mo.
Sheffer, Mark	Maisonpol, Russia.
Sprague, Roy Elliott	Farmington, Mich.
Tedrow, Harvey Louis	St. Joseph, Mo.
Townsend, Frank Edgar	Belgrade, Mo.
Townsend, Richard H	Aspen, Colo.
Walker, John Perry, Jr	Rolla, Mo.
Young, Carl Deuel	Fargo, N. Dak.
Zimmerman, George Henry	Romney, W. Va.

SOPHOMORES.

Andrus, D. E	Rockford, Ill.
Baumbach, John Kenneth	Maplewood, Mo.
Bilderback, Alexander Scott	Kansas City, Mo.
Blake, Harold	St. Louis, Mo.
Bland, John Lilburn	Lebanon, Mo.
Bribach, Oscar Nicholas	St. Louis, Mo.
Broughton, Eugene Harding	Jefferson City, Mo.
Caplan, Frank	St. Louis, Mo.
Conover, Cairy C	Carrollton, Mo.
Coover, Louie L	Springfield, Mo.
Copelin, Leonard Stephen	Great Falls, Mont.
Cronk, Arthur Harrison	Omaha, Neb.
Cushwa, Claude	Independence, Mo.
Elbelt, William Henry	St. Joseph, Mo.
Fogarty, Edmond Allen	Sandcliffs, Mont.
Geringer, Otto George	Chicago, Ill.
Gleason, Augustus William	Chicago, Ill.
Gray, Walter Berry	Louisiana, Mo.
Hackwood, Arthur Wellesley	Baxter Springs, Kan.
Hayes, Dale Irwin	Rock Island, Ill.
Hecht, Leon Morse	Nashville, Tenn.
Herndon, Frank	Lebanon, Mo.
Hollister, Scoville Edward	Marshall, Mo.
Irwin, Joseph Stewart	Louisiana, Mo.
Katz, Edgar Douglas	Kissimmee, Fla.
Katz, Howard M	Kissimmee, Fla.
Kinney, Robert Noel	Rolla, Mo.

Kranzthor, Fred	Eagle Pass, Texas.
Lightman, Morris	Nashville, Tenn.
Lynton, Edward	Ipswich, Eng.
Lyons, Clyde	Springfield, Mo.
McFadden, Edwin Cook	Chicago, Ill.
McKibben, Harold Dennis	Kansas City, Mo.
McNair, Stuart Strathy	New York, N. Y.
Miller, Winlock W., Jr	Kansas City, Mo.
Molyneux, Guy M	Sandpoint, Idaho.
Morris, Edwin Robinson	Jefferson City, Mo.
Myers, Warren Prescott	Prescott, Ariz.
Naylor, Arch Waugh	Marshall, Mo.
Porri, William	St. Louis, Mo.
Pratt, George H	Detroit, Mich.
Radcliffe, Donald Newson	St. Louis, Mo.
Raible, Norman William	Hannibal, Mo.
Robinson, Eugene Charles	Independence, Mo.
Schilling, George William	Freeport, Ill.
Schmich, Matt, Jr	Freeport, Ill.
Shaw, Harry	St. Louis, Mo.
Shaw, Thomas Edward	West Haven, Conn.
Sherry, Homer Kent	Lyndon, Kan.
Smith, Charles Albert	Philadelphia, Pa.
Smith, Marshall Raymond	Rolla, Mo.
Smith, William Bryce	Joplin, Mo.
Stephenson, William Pittman	Nevada, Mo.
Thomas, George Sylvester	Chicago, Ill.
Tway, Robert Raymond	Springfield, Mo.
Ustick, Edward Thomas, Jr	St. Louis, Mo.
Wemhaner, Oscar Christopher	Warsaw, Ill.
Willmott, Miller E	Liberty, Mo.
Wright, Clark Watson	St. Louis, Mo.

FRESHMEN.

Agnew, Samuel Lester	Doe Run, Mo.
Barrett, W. H., Jr	Weir, Kan.
Beach, Philip Sydney	Prescott, Ariz.
Benham, Willard Miles	Cobden, Ill.
Bland, Clark C	Rolla, Mo.
Boucher, Leo	Marshalltown, Iowa.
Boyle, John Clarence	Trinidad, Colo.
Bramson, Charles	New York, N. Y.
Brewer, Jesse H	Batavia, N. Y.
Brewer, William Francis	Carlinville, Ill.

Brooks, Herbert Ivey	Sheridan, Wyo.
Brown, Alvin Bovell	Sedalia, Mo.
Castillon, Tirso	Torreon, Mexico.
Cepeda, Miguel Leon	Jimenez, Mexico.
Clayton, Bert	Rolla, Mo.
Clayton, Charles Yancey	Hannibal, Mo.
Cody, Frank Wesley	St. Joseph, Mo.
Dickson, Frank Paul, Jr	Kansas City, Mo.
Donaldson, James Floyd	Kansas City, Mo.
Faulkner, Ward	Checotah, Okla.
Fendorf, Charles Ernest	Tuscumbia, Mo.
Garretson, Leona Belle	Rolla, Mo.
Halley, Earl	Auxvasse, Mo.
Hanes, Neibert Bartram	Springfield, Mo.
Hopkins, James	Ramey, Pa.
Houghtlin, William Harry	Jerseyville, Ill.
Johnson, Frank Lindley	St. Louis, Mo.
Kadell, Carl Peter	St. Louis, Mo.
Kline, Annie E	Rolla, Mo.
Knickerbocker, Gould	Clymers, Ind.
Leasure, La Vere	Larned, Kan.
McFarland, Russel	Crawfordsville, Ind.
Marshall, Holman	Sioux City, Iowa.
Needles, Enoch Ray	Kansas City, Mo.
Nowlan, Harry H	Cheyenne, Wyo.
Runnels, Ralph Willard	Kansas City, Mo.
Seward, J. F	Hillsboro, Ill.
Sickly, Robert Glenn	Iola, Kan.
Smith, Clyde Othello	Joplin, Mo.
Taylor, Bright Hopkins	Newport News, Va.
Thrush, Harry Alfred	Warsaw, Ind.
Tiernan, James Peter	Kansas City, Mo.
Webster, John Nixon	Creston, Iowa.
Whiteley, Harold Earl	Kansas City, Mo.
Wilson, Ernest C	Mt. Vernon, Ind.

SPECIAL STUDENTS.

Geringer, John Charles	Chicago, Ill.
Hassett, James Lester	Papillion, Neb.
James, James Rush	Springfield, Mo.
Leavitt, James Blaine	Houston, Mo.
Maxwell, Arthur Byron	Chico, Texas.
Purdon, Arthur	St. Louis, Mo.
Roberts, P. A	Joplin, Mo.
Wilson, James	El Oro, Mexico.
Wilson, Thomas	El Oro, Mexico.

ENROLLMENT BY STATES AND COUNTRIES.

Arizona	4
Arkansas	1
California	1
Colorado	7
Connecticut	2
Florida	2
Georgia	1
Idaho	3
Illinois	29
Indiana	5
Iowa	7
Kansas	7
Kentucky	1
Massachusetts	2
Michigan	2
Mississippi	1
Missouri	110
Montana	2
Nebraska	2
New York	7
North Dakota	1
Ohio	3
Oklahoma	1
Pennsylvania	2
South Dakota	1
Tennessee	2
Texas	4
Utah	1
Virginia	1
West Virginia	1
Wyoming	3
Chili	1
China	2
England	1
India	1
Mexico	7
Peru	2
Russia	1
Total	231

ALUMNI.

Alexander, Curtis, '84............................*Garfield, Utah*
Utah Copper Co.

Alexander, Raphael Currier, '03..............*Medicine Lodge, Kan.*

Alexander, Thompson, '01...........................*Chaffee, Mo.*
Engineering Department, St. Louis and San Francisco Railroad.

Ambler, John Owen, '06...........................*Cananea, Mexico*
Cananea Consolidated Copper Company.

Anderson, Hector George Sylvester, '08................*Kelvin, Ariz.*
Ray Consolidated Copper Co.

Anderson, Perry Barton, '97......................*Ft. Madison, Iowa*

Armstrong, Richard Edward, '08,
150 N. W. Temple, Salt Lake City, Utah
Engineer, with Utah Consolidated Copper Co.

Baker, Arnold George, '07..........................*Chouteau, Mont.*

Baker, Charles Armstrong, '08............................*Ely, Nev.*

Barker, Ralph, '98.......................................*Chicago, Ill.*

Barrett, Edward Phillip, '09.........................*Wilburton, Okla.*
Instructor in Chemistry, Oklahoma School of Mines.

Bartlett, Albert Babbitt, '07.........................*Cheyenne, Wyo.*
Consulting Mining Engineer.

Barton, Robert Arthur, '06.............................*Vernon, B. C.*

Baueris, William Albert, '09...........*10216 Lowe Ave., Chicago, Ill.*

Bean, William Yantis, '78.................*510 Pine St., St. Louis, Mo.*

Beard, John Warren, '09......*Care of Ophir Tunnel, Smuggler, Colo.*

Bedford, Robert Hardy, '06.........................*Tombstone, Ariz.*
Mining Engineer.

Bell, Frank Rolla, '03...........................*Bartlesville, Okla.*

Benedict, Ralph Robert, '08.........*659 Park Ave., Kansas City, Mo.*
City Engineering Department.

Black, James Kenney, '04..............................*Clayton, Mo.*
Instructor in Chemistry, Washington University.

Bland, George Vest, '04...............................*Sulzer, Alaska*
Superintendent, Sulzer Mine.

Bowles, John Hyer, '08.................................*Granby, Mo.*
Assayer, Granby Mining and Smelting Co.

Boyer, Fred Tete, '09...........*3633 Shenandoah Ave., St. Louis, Mo.*
Care of National Lead Co.

Boyer, George Hewitt, '08.....*R. F. D. No. 8, Jefferson Barracks, Mo.*
Chemist, Continental Portland Cement Co.

Brooks, John McMillen, '06.........................*Knoxville, Tenn.*

Brown, Joseph Jarvis, Jr., '05.......................*Wilburton, Okla.*
Professor of Metallurgy, Oklahoma School of Mines.

Brown, William Ernest, '07............................*Denver, Colo.*

Brown, Wilton Rutherford, '78..............................

Buckby, De Nard Wilson, '01....................*Whitehall, Mont.*

Burgher, Mark Bernardi, '06....................*Hannibal, Mo.*
City Engineer.

Buskett, Evans Walker, '95.........*4262 Delmar Ave., St. Louis, Mo.*

Buskett, Mary P., '93..............................

Butler, Reginald Henry Brinton, '09,
La Libertad, Jerez, Nicaragua, Central America
Javali Mine.

Cameron, John Simpson, '97....................*Lehigh, Okla.*
Coal Mine Operator.

Caples, James Watts, '05....................*Salmon, Idaho*
Lemhi Engineering Co.

Carnahan, Thomas Samuel, '04.........*P. O. Box 296, Tonopah, Nev.*
General Manager, Tonopah-Liberty Mining Co.

Carson, Arthur C., '80....................*Butte, Mont.*
Manager, North Butte Copper Co.

Cavazos, Enrique, '09...............*Ltd., Mazapil, Zacatecas, Mexico*
Mazapil Copper Co.

Chamberlain, Ernest Lorenz, '09..........*Box 1017, Memphis, Tenn.*
Mississippi River Commission.

Chamberlain, Harry Carleton, '05....................*Gila Bend, Ariz.*
Cornelia Copper Co.

Chamberlain, Santiago, '00.........*Conception Del Oro, Zac., Mexico*
Campania Minera.

Christopher, James Knight, '05,
317 Board of Trade Bldg., Kansas City, Mo.

Clark, George Clough, '99....................*Tucson, Ariz.*
Clark Engineering Company.

Clark, William Newton, '09....................*Ottumwa, Iowa*
Engineer, Phillips Fuel Co.

Clarke, William Danels, '09....................*Garfield, Utah*
Utah Copper Co.

Clary, John Henry, '05....................*Wallace, Idaho*
Moore and Clary, Engineers and Assayers.

Claypool, Wm. M., '84....................*Hollywood, Cal.*

Cole, George W., '87..............................
Deceased.

Compton, James Crawford, '09....................*Emporia, Kan.*
Kaw Paving Co.

Conrads, Ralph Augustus, '04..........*El Oro, Mexico D. F., Mexico*
Esperanza Mining Co.

Cook, Eldon Everett, '07....................*Osborn, Mo.*

Cook, Paul Richardson, '07....................*Salt Lake City, Utah*
Engineering Department, Oregon Short Line R. R.

Coppedge, Lindsay L., '78..............................
Deceased.

Cowen, Herman Cyril, '95..........................*Cementon, N. Y.*

Cowles, Frederick Ragland, '01......*16 E. 34th St., Kansas City, Mo.*
University Preparatory School.

Cowperthwaite, Thomas, '05.................*Box 794, Warren, Ariz.*
Engineering Department, Calumet and Arizona Mining Co.

Cullings, Jay, '86....................................*Pueblo, Colo.*
Assistant Bridge Engineer, A. T. & S. F. R. R.

Cummins, Robert Patrick, '05.........*3835 Page Ave., St. Louis, Mo.*
Engineering Department, Frisco Railroad.

D'Arcy, Arthur Ignatius, '03...........................*Mina, Nev.*

Dailey, Cornelius Mark, '02.....*Care of Edward Flad, St. Louis, Mo.*

Davis, Floyd, '83......................*1659 Broadway, Denver, Colo.*
Consulting Mining Engineer.

Dean, George Reginald, '90.............................*Rolla, Mo.*
Professor of Mathematics, Missouri School of Mines.

Dean, George Walter, '97...............*La Paz, Bolivia, So. America*
Consulting Engineer, Pan American Tin Co.

Deegan, Francis J., '75...
Deceased.

Delano, Lewis Alfred, '04........................*Bonne Terre, Mo.*
Assayer, St. Joseph Lead Co.

DeLay, Theo. Stuart, '94..

De Waters, Roy Haywood, '09.......................*St. Louis, Mo.*
Chemist, Bishop Manufacturing Co.

Don, De Forrest, '09.............................*Philipsburg, Mont.*
Granite-Bimetallic Consolidated Mining Co.

Draper, James Clark, '01...................*Frisco Bldg., Joplin, Mo.*
Consulting Mining Engineer.

Dudley, Boyd, Jr., '08...................................*Rolla, Mo.*
Instructor in Metallurgy and Ore Dressing, Missouri School of Mines.

Duncan, Gustavus A., '74............................*Nelson, Nev.*
Manager, Nevada-Eldorado Mines Co.

Dunkin, Damon Duffield, '04.......................*Wilburton, Okla.*
Professor of Mining, Oklahoma School of Mines.

Dwyer, Edward P., '95................................*Joplin, Mo.*
Mine Operator.

Dyer, T., '94..*Rolla, Mo.*

Eardley, Albert Edwin, '97...................*Carriso Springs, Tex.*

Easley, George Albert, '09..............*La Paz, Bolivia, So. America*
Superintendent, Pan American Tin Co.

Elicano, Victoriano, '09....................*Massinloc, Tambles, P. I.*

Emerson, Cyrus, '76...............................*Pittsburg, Kan.*

Ericson, John T. E., '07..............*1227 Caldwell St., Clairton, Pa.*
Chemist, with Carnegie Steel Co.

Fach, Chas. Albert, '00.............................*St. Louis, Mo.*

Fay, Albert Hill, '02..................*505 Pearl St., New York, N. Y.*
Engineering and Mining Journal.

Fellows, Aubrey P., '07..............................*Collinsville, Ill.*
Chemist, St. L. S. & R. Co.

Fernandez, Abraham Leonardo, '00...............*Monterey, Mexico*

Florreich, Phillip, '95.................................*St. Louis, Mo.*
U. S. Engineering Corps.

Foster, Leo Joseph, '04..............................*Montrose, Colo.*
U. S. Reclamation Service.

Fowler, James Duncan, '08..........................*Montrose, Colo.*
U. S. Reclamation Service.

Fraizer, Isaac Peter, '00..............*Box 652, Salt Lake City, Utah*

French, Chas. Lewis, '08.................................*Bisbee, Ariz.*

Fulcher, James E., '86............*1348 Wilmot St., Ann Arbor, Mich.*
Instructor in Descriptive Geometry and Drawing, University of Michigan.

Gallaher, Phillip C., '84..........*610 Harrison Ave., Leadville, Colo.*
Chemist, Iron Silver Mining Co.

Garcia, John Adrian, '00..............*Old Colony Bldg., Chicago, Ill.*
General Superintendent, Brazil Block Coal Co.

Gardiner, William Alexander, '06....................*El Oro, Mexico*
Esperanza Mining Co.

Garrett, Leon Ellis, '01.....................................*Rolla, Mo.*
Assistant Professor of Mathematics, Missouri School of Mines.

Garst, Harvey Oden, '09...........................*Pocatella, Idaho*
Engineering Department, O. R. & N. R. R.

Garvens, Oscar E., '76...............................*E. St. Louis, Ill.*

Gibb, Frank W., '82..................................*Little Rock, Ark.*
Gibb and Sanders, Architects.

Gill, John Holt, '74...
Deceased.

Gill, William Harris, '03..........................*Bartlesville, Okla.*
National Zinc Co.

Gormley, Samuel James, '95................*Lima, Peru, So. America*
Smelter Superintendent, Cerro de Pasco Mining Co.

Gottschalk, Victor Hugo, '98...............................*Rolla, Mo.*
Professor of Chemistry, Missouri School of Mines.

Grabill, Lee R., '78............................*Washington, D. C.*
Assistant Engineer, War Department.

Greason, John D., '76...
Deceased.

Green, Cecil Theodore, '06..................*Rosario, Sinaloa, Mexico*
Care of Minas del Tajo.

Greenidge, Samuel Marshall, '02...................*Cananea, Mexico*
Cananea Consolidated Copper Co.

Gregory, James Albert, '05..................................*Rolla, Mo.*

Grether, Walter Scott, '06.....*Care of Hotel Tooele, Tooele City, Utah*
International Smelting and Refining Co.

Griffith, William Thomas, '06........................*St. Louis, Mo.*

Grine, Harry Adam, '04............*3627 Weber Road, St. Louis, Mo.*

Grove, Claude Devlin, '94.....................*Marblemount, Wash.*
Skagit Queen Consolidated Mining Co.

Guntley, Edward Anthony, '06........................*McGill, Nev.*

Hall, William Simpson, '09................*Pachucha, Hdgo., Mexico*
Sampler, Real del Monte, Minas Barron.

Ham, Roscoe Conkling, '09.........................*Warren, Ariz.*

Hand, Horace Alonzo, '06......................*St. Lake City, Utah*

Hanley, Herbert Russell, '01................................
Deceased.

Hare, Almon W., '75...
Deceased.

Harper, Frank William, '08......................*Courtland, Ariz.*
Chief Chemist, Great Western Mining Co. and C. & A. Mining Co.

Harris, Geo. W., '04..........................*Guanajuato, Mexico*
Peregrina Mining and Milling Co.

Hartzell, Henry H., '06..............................*Granby, Mo.*
Smelter Superintendent, Granby Mining and Smelting Co.

Hase, Herman Carl, '08............................*Morenci, Ariz.*

Hatch, William Peter, '07.......................*Kansas City, Mo.*

Hatchett, Roger Hansom, '99.................................

Hauenstein, Frederick, '03..........................*Beatty, Nev.*
Locating Engineer, Los Vegas-Tonepah R. R.

Heck, Elmer Cooper, '05...................*Hermosillo, Son., Mexico*
Verde Grande Copper Co.

Hendricks, James Otto, '99.........................*Bolivar, Mo.*

Herdman, George Walker, '94...................*Neosho Falls, Kan.*

Hinsch, Van Buren, '09...........................*Wilburton, Okla.*
Instructor, Oklahoma School of Mines.

Hoffman, Ray Eugene, '05..........................*Hannibal, Mo.*
Assistant Engineer, Atlas Portland Cement Co.

Horner, Preston King, '06,
Tanganyika Concession, Ltd., Katanga, Congo Free State, Africa

Hoyer, Rudolph C., '79..........................*Montgomery, Ala.*
U. S. Engineer Office.

Hughes, Victor Harmon, '09...........................*Rolla, Mo.*
Geologist, with Missouri Bureau of Geology and Mines.

Hunt, Lamar Horatio, '05,
Hacienda de Loreto, Pachuca Hidalgo, Mexico
Mill Foreman.

Hynes, Dibrell Pryor, '08.......................*Cananea, Mexico*
Sampler, C. C. C. Co. Concentrator.

Jackling, Daniel C., '92.....................*Salt Lake City, Utah*
General Manager, Utah Copper Co.
President, Ray Consolidated Copper Co.

Jochamowitz, Simon, '09............*62 Rue Maubenge, Paris, France*
Graduate Student, Royal School of Mines.

Johnson, Edward Mackay, '92.........................*Golden, Colo.*
Chemist, Golden Smelter.

Johnson, Horace Asahel, '08.........................*Millers, Nev.*

Jones, Elston Everett, '08............................*Globe, Ariz.*

Jones, Fayette Alexander, '92,
Room 4, Armijo Bldg., Albuquerque, New Mexico
Consulting Mining Engineer and Geologist.

Kellogg, George Fred, '08..........................*Skidmore, Mo.*

Keniston, Carl Winthrop, '09...........................*Rolla, Mo.*
Station Assistant, Mining Experiment Station.

Kersting, Felix John, '97..........................*Columbia, Mo.*
State Highway Commission.

Kibe, Harry Clay, '09...............................*Newburg, Mo.*
Superintendent, Newburg Mining and Milling Co.

King, Charles Leclair, '04,
Cia De Real Del Monte y Pachuca, Pachuca, Mexico

Kirkham, John Edward, '95............................*Ames, Iowa*
Associate Professor of Civil Engineering, Iowa State College.

Koeberlin, Frederick Richard, '01.................................

Lachmund, Oscar, '87.........*Newhouse Bldg., Salt Lake City, Utah*
Consulting Mining Engineer.

Laizure, Clyde McKeever, '05........................*Millers, Nev.*
Chas. C. Moore & Co.

Lehman, John Ludwig Gustav, '05.....................*Monett, Mo.*

Lintecum, Charles Lafayette, '05...................*Telluride, Colo.*
Engineer, Liberty Bell G. M. Co.

Logan, Louis Sublettle, '03...........*408 N. 11th St., St. Joseph, Mo.*

Lohman, Harry William, '04...................*Breckenridge, Colo.*
Manager, Colorado Gold Dredging Co.

Long, James Carter, '07..............................*Victor, Colo.*

Loveridge, Frank Richard, '09......*7802 Vermont St., St. Louis, Mo.*
Chemist, with Continental Portland Cement Co.

Luther, Walter Adams, '03..........................*St. James, Mo.*

Lyman, George Edwin, '02.......................*Edwardsville, Ill.*
Chief Engineer, Madison Coal Corporation.

Lyneman, Felix Anthony, '08.................*Box 712, Denver, Colo.*

McCarthy, John Henry, Jr., '05....*6609 Florisant Ave., St. Louis, Mo.*

McCrae, Rowe Francis, '09..........................*Garfield, Utah*
Utah Copper Co.

McElroy, William, '09..............................*Ft. Scott, Kan.*
City Engineer.

McGrath, John E., '76..........................*Washington, D. C.*
Coast and Geodetic Survey.

Mann, Horace Tharp, '08..............................*Rolla, Mo.*
Instructor in Metallurgy, Missouri School of Mines.

Mapes, Harold Thomas, '08....*La Muta No. 501, Mexico D. F., Mexico*
Oaxaca Iron and Coal Co.

Martin, Walter Guy, '96..............................*Denver, Colo.*
Ore Purchasing Agent, United Zinc and Chemical Co.

Martinez, Carlos Efrin, '02...................*Saltillo, Coah., Mexico*
Saltillo Light Co.

Martinez, Justo G., '86..

May, Lawrence, '02...............................*Winthrop, Cal.*
Bully Hill Copper Mining and Smelting Co.

Mazany, Mark Stephen, '09..........................*Garfield, Utah*
Foreman, Converter Department, Garfield Plant, A. S. & R. Co.

Michael, Pearl Frederic, '09..............................*Rolla, Mo.*

Millard, Sallie E., '91 (Mrs. Cornelius Roach)....*Jefferson City, Mo.*

Millsap, Thos. H., '77..
Deceased.

Minger, Wm. C., '76...........................*Idaho Springs, Colo.*
Assayer, Chamberlain-Dillingham Sampling Co.

Minor, Cyrus Edward, '04.........................*Cananea, Mexico*
Cananea Consolidated Copper Co.

Mix, Ward Barr, '08.............................*Edwardsville, Ill.*
Engineering Department, Madison Coal Corporation.

Moore, Frederick Arnold, '08....................*Herculaneum, Mo.*
Assistant Superintendent, St. Joe Lead Co.

Moore, Stanley Ralston, '05.........................*Wallace, Idaho*
Moore and Clary, Engineers and Assayers.

Morgan, Glenn Beckley, '04...................*Box 138, Fargo, N. D.*
U. S. Geological Survey.

Morris, Edmund James, '02...
Deceased.

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SOME OF THE ESSENTIALS OF SUCCESS*

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President of the Case School of Applied Science

For several reasons it gives me great pleasure to be here today and to take part in these Commencement Exercises. In the first place, I am fairly well acquainted with the work which this institution is doing and has been doing for many years, and I know that it ranks among the very best schools of its kind in the country. In the second place, I have been connected with a technological school for over twenty years, and naturally I am interested in every institution training men for scientific and engineering work. In the third place, soon after I graduated from college I went into the southwestern part of our country, among the Rocky Mountains, and for three years had an assay office and was brought intimately in contact with mining operations. As I look at the young men who are to graduate from this mining school to-day, I think of the time when I, a recent graduate with small knowledge but with many hopes, hung out my sign as an assayer and took part to a very limited degree in the development of the mining industry. At that time, I believe there were but three mining schools in the United States; nearly all the assayers and mining engineers were practically trained men and not men of college or technological education. Since then matters have materially changed. To-day very many of the separate technological schools have mining departments, and a large number of universities—especially the state universities—are likewise provided. This change could not have taken place without some good reason for it. The evolution in mining education has followed the evolution in all engineering training, and that, in turn, has simply followed in the line of education in all professional pursuits. Some of you can doubtless remember when lawyers and physicians were trained under some practitioner because there were no schools in which they could receive professional education. Now it rarely ever happens that men in either of these classes go into an office to receive their preparation. Sixty years ago all engineers were practically educated, and many of those so trained would doubtless have laughed at the idea of teaching a man in a school to become an engineer. To-day our engineering colleges are turning out thousands of young men every year, and there is so great a demand for the graduates that the supply is still insufficient. The difference between the technically trained engineer and the man who tries to get into enginering work by starting in at the foot of the ladder, working his way up, was well illustrated by the experience of a young man who graduated from one of our first engineering schools nearly fifty years ago. He sought a position with a railroad-locating party. The chief of the party told him that he could offer him nothing better than a rodman's position, but the boy had some sense and declared that he wanted a job and was not looking for a high position; so he became a rodman. In the course of a few weeks the level-man of the party left, and as the technical graduate was the only one, except the chief, who could handle a level, he was at once promoted to the vacancy. Not long after this, the transit man resigned, and the technical graduate was again promoted, because he was the only one of the party who had been trained to the use of this instrument. When winter came all of the untrained men were discharged, because field work could not be carried on, but the technical man was taken into the office and put at drafting work. He had been trained in the technical school to do all kinds of engineering work, and hence could fit into any opening which offered. The untrained men who hoped to learn by experience were soon distanced and left behind.

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*Commencement Address, June 1, 1910.

That there is a great necessity for technically trained men in mining engineering is evidenced by the fact that a successful mining engineer must understand surveying, must be a good draftsman, must be thoroughly versed in chemistry and metallurgy, should be a good mechanic, must have some knowledge of practical electricity and steam engineering, and must have been thoroughly trained in ore dressing. No man can learn all of these subjects except in a school where there are experts to teach and laboratories where practical work can be carried on.

The necessity for trained mining engineers is also shown by the extent of the mining industry. Last year the United States produced ninety-nine million dollars' worth of gold, twenty-eight million dollars' worth of silver, fifty-one million tons of iron ore, four hundred and forty thousand tons of lead, and one billion, one hundred and seventeen million pounds of copper, to say nothing of five hundred million dollars' worth of coal and smaller quantities of the rarer metals. An industry so vast as this must have properly trained men to conduct it, and the technical schools with their mining departments are trying to supply this need.

A few weeks ago I listened to an address upon the subject "Engineers as Leaders." The speaker proceeded to compare the number of prominent engineers with the number of men prominent in other professions, and then drew certain comparisons from his figures. I have never felt very much interest in the question of preparation in a technical school for leadership, either among engineers or in the world at large. Only a few can be leaders, the large majority must hold subordinate positions. If the technical school made a special business of trying to educate the leaders, it would not properly educate the great bulk of its students, for they will be obliged to carry on the everyday, ordinary work which falls to most engineers. But there is one point in regard to education which does interest me exceedingly; that is, education for success. Now, success is a very much abused term. It has a certain definition in the dictionary, but its meaning to an individual generally depends upon his views of life. One man considers that success does not come to him unless he acquires great wealth; another, to be successful in his own estimation, must receive honors from his fellow citizens; another must reach the top of his profession, and so on. It is evident that if these are the views of all men in regard to success, few of them will attain their goal—for comparatively few can be very wealthy, but few can hold distinguished rank, but few can be at the top of their professions.

My definition of success is this: A man is successful when he continually does all that it is possible for him to do. All men are not alike. One man may have greater intellectual power than others; another may have greater bodily strength; another may have a faculty of keen insight; another may have the peculiar quality of getting along well with other men. Now, the man of medium ability cannot hope, as a rule, to reach the same high goal that can be attained by the man of great intellectual endowments; but I claim that if the former accomplishes all that his powers will enable him to accomplish, he has been just as successful as the latter, although he may not have done as much of the world's work. Whether you agree with me or not in my definition of success, you will at least allow that every man should try to accomplish as much as possible—that he should at all times do his very best.

After twenty-seven years' experience as a college professor and a college president, I am led to the belief that a very large percentage of the graduates of our technical schools do not achieve success according to the definition which I have just given. I have arrived at this conclusion most unwillingly. Perhaps many people will not agree with me. They will acknowledge that some technical graduates are not successful, but they will not acknowledge that the majority, or at least a very large percentage of the men who come from our engineering colleges do not meet with success. They will say, perhaps, that the technical graduate is a picked man, and this is true. Most of our technical colleges graduate only forty to fifty per cent of the students who enter them. These men have a thorough training in theoretical and practical subjects for four years—they are a picked class. It will, also, be said, perhaps, that for every graduate of the average technical school there are from two to six positions open. That also is true. The best of our technical graduates have many positions offered them either before graduation or soon after, and most of them go to places which offer promise of advancement and fair remuneration, and they do good work. But this has nothing to do with my contention that a very large percentage of technical graduates do not meet with success according to the definition which I have given of success—that is, they do not accomplish all that is in them to accomplish. Now, I regret that this is so, because I consider it absolutely unnecessary, and I fully believe that it is possible for every technical graduate to achieve the success which I have defined. Perhaps some one might ask, "Accepting your proposition as true, is it the fault of the graduate that he does not attain this success?" My answer would be that it is not in all cases the fault of the graduate. He very frequently fails to attain the highest success because he does not understand the conditions of success. I wish, therefore, to tell you what I think the essentials of success are for a technical graduate. Many of these essentials might apply to other men as well, but as I am addressing the graduating class of an engineering school it seems proper that I should direct my remarks especially to them.

I shall speak of success under two heads:

First, that success which has to do with individual traits and qualities; and second, that success which is concerned with the highest good to the nation at large.

I trust none of you imagine that I am going to present to you some abstruse, philosophical theories, or that I am going to take up the question of the psychology of men's actions and their results. There is nothing abstruse in what I propose to say; the propositions are as plain and simple as the alphabet; and it is because they are so plain, so common, so everyday, that many people absolutely fail to see them.

My first essential of success is health. Nature endows most men with bodies that are strong, and minds that are fairly alert, but the majority of men take very little pains to keep either one of these up to the highest state of efficiency. The engineering colleges expect their football teams to go into training during the season. Their diet, their exercise, their sleep are all prescribed, and every member of the team is glad to follow out the instructions given because he has one goal in mind—the success of his team and his college. He knows he is going to be pitted against men of other teams and that he must give the best possible account of himself in the struggles through which he is to pass. This is a part of college life—its play. This training is gone through with for the sake of no great purpose nor for any lasting result. The engineering graduate goes out into the world, where he finds himself up against thousands of other men, where he has to contend with the forces of nature and inexorable natural laws, and he never thinks of keeping himself in training for this contest. He needs to have his mind constantly alert, his body in the finest condition, yet he takes no pains to see that these results are attained. Most young men, after they go out into the world, keep late hours, are not careful about their diet, do not take any exercise at all, except spasmodically—and yet they expect to succeed against the opponents who are everywhere trying to distance them. The man who is to accomplish all that it is possible for him to accomplish, who is to make the greatest success of his life, must train for it as the athlete trains for his struggles. After one has abused his stomach by over-eating and overdrinking, he cannot expect to have a clear intellect, with which to win victories in his profession. If you want success, train your bodies as well as your minds for it.

The man who is to be successful must fit into the scheme of things or, in the slang of the day, he must "get on to his job." When the graduate takes his first position, he finds everything strange and new. He must thoroughly learn the duties of his new place; he must find out how his work is related to the work of men in other departments of the same concern; he must establish himself on a friendly footing with his fellow workmen—the sooner he does this the sooner his first step toward success will be taken. After the graduate has firmly established himself in his place, has learned to do his work easily and well, has made friends with those about him, he should begin to study the duties of the man next above him—not with the idea of driving this man from his place, nor of criticising the way in which he does his work, but simply because success lies in that direction. Every man wants advancement, and advancement usually comes to the man who is ready and prepared for it. A few weeks ago in traveling from New York to Cleveland I sat next to a young fellow who, when he found I was from Cleveland, told me that that was his home, and said that he had just been to New York to buy goods for his house. He had recently been appointed the head of a department in the great wholesale concern with which he was connected. I found that he wanted to talk, and I was very glad to listen. He said he entered the employ of this concern when he was a boy and ran the elevator for two or three years; he was so small he could not do anything else. Then he looked round to see if he could not get something better, and the firm finally gave him a clerkship in one of the departments. He told me that he had constantly made a study of the next place above him, to see whether he could perform the duties of the man holding it, and that he always tried to be ready to do the work of the man next ahead. At a comparatively early age he had been promoted to the headship of his department. Now he told me this very simply and very plainly, without any boasting and without any idea, I imagine, of the fact that he was telling me one of the first principles of success. I believe it is generally true, that if a man is ready for promotion, sooner or later it will come to him. Most of you undoubtedly have heard men say, "No, I am not going to work any harder; I am doing now all I am paid to do." The man who achieves success and secures advancement always does more than he is paid to do; that is the kind of man any firm wants. No employer will hire a man unless he can make money out of him, and the more money he can make, the better pleased the employer is with the man and the more desirous he is to advance him. This is one of the paths to success—do more than you are paid to do, and—do it cheerfully.

The young engineer must know more than his own work or the work of the man just ahead of him. He should study the work of his company or his firm, and find out its relation to that of other companies and firms. He should know where the firm's raw material comes from, approximately what it costs, all the steps in its treatment, what the final product is, where it is sold, what it is used for; in fact, he should endeavor to gain a comprehensive idea of the whole business.

The successful engineering graduate will subscribe for the leading technical magazines in his line of work, and he will not only subscribe for them—he will read them, in order that he may keep posted in regard to what men in his profession are doing, not only from the engineering standpoint, but from the manufacturing standpoint as well. Too many technical graduates never take a technical journal. They say they do not need it for the work they are doing, which is probably true, and if they continue in that frame of mind, the probability is, they will never need to take the journals, because they will not rise to positions of high enough responsibility to make it necessary. The successful man—the man who is doing all that is in him to do—must know what other men are doing, and he must put this knowledge to use in the work which he does from day to day.

I believe every engineering graduate should keep a card catalog of articles and books which he reads, and these cards should give the information under so many different heads that it surely can be found when needed. Almost every man has at some time in his career wanted very much some article which he remembers having read but cannot place. Usually, this occurs to men every week or every day. Knowledge is valuable only as it can be used. No one can remember everything which he has read; no one can know all there is to be known; but every engineering graduate should know where to go to find the information necessary in the successful pursuit of his profession. This means knowing how to search encyclopedias, magazines, books, etc., and I think the practice of keeping a card catalog of the important things read will pay for itself many times over. Do not be afraid of a little extra work of this kind.

The man who is looking for the highest success should study men who have been successful, to find out the secret of their success. Successful men have many qualities. I believe it will always be found that they are educated. Now, this does not mean that they have had a college education, but it means that they have educated themselves for the things they have had to do and the lives they have had to lead; and this is the kind of an education that every man must have if he is to rise above his fellow-men, no matter whether he has previously received a college education or not. A technical education does not necessarily mean success; there are many other essentials. Very frequently parents think that if a boy goes through college he ought to become a successful man, and they sometimes intimate as much to college faculties. But the fact is, if a college is to make a successful engineer out of a student the boy must have some brains to start with. Mental ability, correct habits of thought and work, intelligence, power of application, the ability to get along with men, love of work, high character, are all necessary for success, and I am not sure that a technical education is more essential than any one of these. These qualities should be cultivated by the one who would win success, because they are necessary if the highest goal is to be reached. All men do not have these qualities to the same degree, and a man is not to be held accountable for natural qualities which he does not possess. He is, however, to be held accountable for the way in which he uses and improves the natural endowments which are his. It is this use and improvement of that which nature has given him which I have termed "Success." It is possible for every man to develop his powers to the highest degree, and that is all that any one can expect him to do.

Again, if a man is to be successful in this world, he must have the ability to do things. The American nation demands results, and much will be forgiven him who secures them. A strenuous president may make enemies by some of the things he does, but the nation at large will overlook many mistakes if he is one to whom accomplishment has become a habit. The engineer must do things, because if he does not he is not an engineer. It is the business of men of this profession to take the materials and forces of nature and to use them for the benefit of mankind. The materials may lie in inaccessible places; they may not be in the form or shape necessary for use. But the engineer must overcome these difficulties and transport the material to the place where it can be used and change its form or substance so that it will be serviceable to man. He may run up against some pretty stiff natural laws, and these laws will not change nor step out of the way because the man who wishes to use them is a graduate of a technical school. He must use the laws in the way in which they were intended to be used, and he must make one force counteract another until the desired result is reached. In fact, he is constantly doing things, and this is what makes him such an effective unit in the society of the present age.

I have spoken of some of the individual characteristics which make for success, but the progress of the nation is of much more importance than the well-being of an individual. A man's work cannot be called successful, no matter what it brings to him, if it is detrimental to the nation at large.

It is the business of the mining engineer to take from the earth the ores which contain metals valuable to man, and then to extract these metals so that they may be of use. We do not know when these ores were formed, but we do know that it was a process covering long periods of time, and that they cannot be made during the lifetime of an individual or of a nation. We also know that the supply can be exhausted, and that when this is done we cannot obtain any more. It becomes important, then, that the mining engineer should not only study the methods of obtaining the valuable metals, but that he should know how to do so in the most economical way, and that he should not waste any of the raw material with which nature has endowed the earth. The conservation of our natural resources is one of the great subjects which is interesting our country to-day. Conservation applies to many things, but I wish to speak this morning of its relation to the mining industry, and the part you may bear in it. I believe the path to success for the young mining graduate lies along this line, and in a few words I shall try to show why this is so.

Manufacturing industries depend upon fuel, and cheap fuel is a vital element of our supremacy in the world's markets. The amount used at the present time in the United States is very large. In 1909 the coal mined amounted to about four hundred and fifty million tons, having a value of over five hundred million dollars. The petroleum was valued at about ninety million dollars; natural gas at about fifty million dollars; coke at about one hundred and ten million dollars and artificial gas at about thirty million dollars. The total value of fuels, including by-products, was almost one billion dollars.

Coal is found in almost every section of the United States, twenty-nine out of forty-six states having coal fields. Natural gas and petroleum are also found in many of the states. No matter how large the supply of these fuels may originally have been, a yearly drain such as just mentioned will inevitably in a few years sadly deplete it, and the amount used is increasing every year, and at a very rapid rate. But this is not all; the figures just given are those for the fuel taken from the ground and used, but the amount wasted doubles or trebles this total. Although this latter has not been put to any use, it has been destroyed so far as its future usefulness is concerned.

Natural gas is one of the most perfect fuels in existence. It is found under such pressure that it can be carried long distances and delivered in the factory ready for use. The turning of a cock regulates the supply, and there is no dirt or loss. Many wells which yield small amounts are allowed to waste their supply in the air, and it frequently happens that the product of large wells is more or less wasted because proper piping is not at hand or proper precautions have not been taken. In many oil wells there is more or less gas, and little if any effort is made to secure this supply. One geologist estimates that at least a billion cubic feet of gas per day are allowed to go to waste in the United States. Only one state, Indiana, has passed stringent laws against this waste. This state found her supply of natural gas was rapidly being exhausted and that factories formerly dependent upon it were obliged to change to some other form of fuel. After a large part of the supply had been exhausted, laws were passed forbidding operators to open gas or oil wells until precautions had been taken to save all the gas.

The waste in coal mines is very great. Nearly every coal vein has streaks of sulphurous or bony coal mixed with the first-class material. This contains a large amount of carbon, but is not as valuable as some parts of the seam; it is, therefore, left in piles inside of the mine or dumped upon the culm bank on the outside. The amount of this low-grade coal varies from ten to fifty per cent in every mine, and under the present system of mining and of coal using, this is an absolute loss. As the roofs of coal mines will not support themselves, and as timber is expensive, it is the custom to leave great pillars of coal as supports. As a rule, these pillars are not taken out, and so become absolute waste. In many coal mines there are several layers of the coal separated by shale formation. Some of these are narrow and cannot be mined to advantage; others are so broken up and dislocated by the mining of adjacent seams that it is impossible to take them out. All of these causes and perhaps some others make up a loss of from forty to seventy per cent of the coal in the average coal mine of the country. As we obtain only thirty to sixty per cent of the coal, it is evident that we are exhausting our coal fields twice as fast as the actual amount of fuel used would indicate.

This immense drain upon the coal supply must very soon have an effect. It has been estimated that our anthracite coal cannot last more than seventy-five years. The bituminous coal will last much longer, but it will become exhausted in those places where it is now used to the greatest extent. The most important coal vein in the United States is in the Pittsburg belt, and is being more rapidly mined than any other. Each acre of land has supplied about eight thousand tons of coal, and at this rate the state geologist of West Virginia estimates that at the beginning of the next century there will be no coal within one hundred miles of Pittsburg. No one can fail to perceive that this will be a terrible blow to the manufacturing industries of that great industrial center. In many sections of the country, where neither anthracite nor bituminous coal is found, large deposits of lignite exist. This lignite can be used for heating purposes in houses, but it is worthless for manufacturing purposes because the amount of ash is so great that it will not produce steam. In sections of country where this is the only fuel supply, it is necessary to bring coal from long distances, which makes it very expensive and puts a great tax upon manufacturing industries.

Our coal measures cover such an extensive area and the supply has seemed so great that the conservation of our fuels has received very little attention until within the past few years. In 1903 the Technologic Branch of the United States

Geological Survey was established in St. Louis, in connection with the Exposition, and since then a very extensive study of the fuel supplies of the country has been carried on. Dr. Holmes, the Director of this Branch, Professor Lord of the Ohio State University, in charge of the chemical work, Professor Breckenridge, formerly of the University of Illinois, who at first had charge of the boiler tests, and Professor Fernald of Case School of Applied Science, in charge of the gas producer and gas engine tests, are all technically educated men. The results obtained have been of an astonishing character. It has been found that the fine coal, the refuse of mines and breakers, hitherto regarded as of little value and sold at an extremely low price, can be made into briquettes at a comparatively low cost, and it is then as valuable as the finest coal that can be obtained. It has also been found that many so-called non-coking coals can, by proper methods, be coked as readily as the best coking coals of Pennsylvania. These two results alone are worth many times as much as this bureau has cost the government, for certain manufacturing industries must have coke for fuel, and in some sections it has been necessary to bring the coke from long distances, because no coking coal was at hand, although large supplies of other coal were easily obtainable.

But perhaps the most wonderful results from these experiments have come through the investigations in regard to the use of coal in the gas producer and the gas engine. With the old processes, we do not obtain on the average more than five per cent of the heat value of our coals. The steam engine utilizes from four to ten per cent, but the gas producer and the gas engine utilize from eleven to eighteen per cent. Coal converted into gas produces, then, two and one-half times as much power as when burned under a boiler. The best Pocahontas coal under a boiler was found to produce .28 hp. per pound of coal per hour, while with a gas producer the same amount of coal produced .96 hp., or 3.34 times as much as when used in the ordinary way. A lignite, which would produce only .10 hp. per pound of coal per hour when used under a boiler, produced .36 hp. when used in a gas producer. A still more interesting fact is that the best Pocahontas coal used under a boiler produced .28 hp. per pound per hour, while a lignite in a producer gave .30 hp. Thus, lignite turned into gas gave more power than the best coal when used under a boiler. These results indicate that there is fuel in almost every part of the United States which can be used to produce power through the gas producer and gas engine, so that the amount of valuable fuel for power purposes has been increased many fold by the work of the Technologic Branch.

It is true that these results, while they show a great improvement over ordinary methods, look small, compared to what should theoretically be obtained. Even the gas engine, under the most favorable conditions, does not utilize over eighteen per cent of the heat value of the coal. There is still a great opportunity for the engineer to devise methods by which a larger per cent of the energy of our fuels can be utilized. The gas engine has been in use in Europe for a number of years, and is now being introduced into this country. There are installations where the horse power runs into thousands, but these are isolated and are principally in connection with steel plants. The average manufacturer hesitates to install a gas engine, because he fears that he cannot depend upon it every day as he can upon the steam engine, and because he knows that it cannot be operated by the same engineer who can operate his steam plant. The steam engine is so simple and has been in use so long that it is very easy to make repairs upon it, and it does not take long comparatively to train a man to use it. The gas engine is more complicated, is not as well understood, and at present there are very few men who are experienced in its use. The greater initial cost of the gas plant, the cost of operating and the feeling which the manufacturer has that it is unreliable, will retard its use, but if our engineers, and especially our engineering colleges, will make the thorough study of this question which it deserves, there is no doubt that within a few years the gas engine will practically supplant the steam engine. The manufacturer wants power, and he wants it as cheaply as it can possibly be obtained. If a new form of prime mover will develop two and one-half times as much power as the old, without too much initial cost or expense of maintenance, the manufacturer will rapidly install the new form. I believe our engineering colleges should install gas plants and make a thorough and systematic study of their use from day to day. In this way their faults can be remedied, and through published reports the manufacturer can be made to feel that they are reliable. At the same time it will be of immense benefit to the students to have a thorough training in the principles and the use of this new form of engine.

This is an iron age. A nation's industrial progress is determined by the amount of iron ore it uses. Gold, silver, tin, lead and many other metals, while useful, could be dispensed with, but iron and copper are indispensable at this stage of the world's progress, and of these two iron is by far the more necessary and the more useful. In 1909 fifty-one million tons of ore were mined, and up to the present time seven hundred and fifty million tons have been mined in this country. The total amount of iron ore available in the United States is about as follows: In Lake Superior, one billion five hundred million tons; in the southern district, two billion five hundred million tons; in the other parts of the United States, five billion tons, or a total of about ten billion tons. The highest grade is found in the Lake Superior district, and hence this ore is in the greatest demand. In 1909 forty-one million tons were mined in this region, and with the present increase in consumption the supply will be completely exhausted by 1940, unless new deposits are discovered. Up to the present time one-thirteenth of the original supply of iron ore in the United States has been used. At the present rate of exhaustion the total amount in the whole country will be used up before the end of the present century. This includes, however, only that supply which is of a high enough grade to be worked at the present time. After that it will be necessary to use lower grades of ore, or we must do what so many European countries do—import from other places. This, of course, would be a great blow to our material prosperity. We have held out position in the industrial markets for iron and steel products on account of the abundance of our iron ore and coal and the consequent low price of both. When it becomes necessary to import either coal or iron, the cost of manufacture will largely increase, and, unless conditions are different from those at present, we shall no longer be an exporting nation. It will be necessary for the engineer to use all of his ingenuity and skill to avert the commercial and industrial disaster which will inevitably come when the supply of iron ore is exhausted. This may be done perhaps by new methods, which will make it possible to use a lower grade of ore and yet obtain the manufactured product at the same price as at present. New alloys of iron will undoubtedly be discovered by the engineer, which will make it possible to obtain the present strength for machines and structures with the use of less material, thus decreasing the amount of ore used. As concrete reinforced by steel takes the place of steel structures, a still greater saving in iron will be the result. This change is inevitably coming, for the progress in this direction during the past few years has been astonishing. The engineer is deeply concerned with methods of transportation, and by substituting water transportation for rail transportation the saving in steel is very great, for the same load can be carried by the former with one-third the steel in the original plant that is necessary when loads are carried by rail.

The same conditions exist with regard to copper and lead and zinc, as well as to the precious and rare metals. All are being taken out of the earth in large quantities every year, and in almost every case there is a great amount of waste. We mine our ores along the line of least resistance, thinking only of securing the greatest amount at the least cost, and caring nothing for the waste which remains upon the dump. These methods will answer, with an inexhaustible natural supply, but under actual conditions they mean destruction of our resources and commercial and manufacturing death to the nation which follows them too long.

These facts have been gathered from government reports and papers written by experts in each of the several divisions of this question. The point which I had in mind and to which I wish to give especial emphasis is, that this work of conservation is the work of the engineer, and if he is to reach the highest success he must bear it in mind in all that he does. I am inclined to think that in some cases the statements in regard to the destruction of our natural resources have been overdrawn, and that the latter will not be totally exhausted in as short a period as some seem to believe, but there is no doubt that the question is a grave one and that it should be faced before it is too late. We should try to avoid waste and unnecessary destruction, and we should also try to make the best possible use of all of our resources. It will be the work of the engineer to accomplish both of these objects. In the past he has been concerned with getting results. If these were obtained, the waste and destruction of the natural product were scarcely considered, but in the future economy of our resources as well as economy in the final result, must receive careful attention.

I believe the engineers of the country are capable of solving these problems and that they will do so if they are given the necessary governmental and private aid.

The engineering colleges of the country will also have a share in this work. They are training the engineers of the future, and from now on they must train them with this problem in view. They must not only give them the principles of engineering practice, but they must show them how the work of the engineer can be carried out with a view of transmitting to our posterity the natural resources, so far as possible, in an unimpaired condition. As has been pointed out in the address, the conservation of some of our natural resources must be accomplished through new inventions. This means that the engineer of the future must be able to do more than the ordinary engineering work which comes to him from day to day. He must be so thoroughly trained in the principles of science and applied mechanics that he will be able to discover new processes and accomplish old results in new and more economical ways. He must be taught more thoroughly than ever before how to unite theoretical and practical knowledge. In short, he must be able to think along scientific and engineering lines.

I have tried to call your attention to some of the elements of success, as I have defined success. It would not be correct to assume that these are all of the elements which make for success, but merely that they are some of them which the engineering student and the engineering graduate should bear in mind. Some of these essentials have to do purely with the individual and will count toward his personal success as well as the advancement of the operations which he may carry on. The others deal with a question of great national importance which will certainly be brought home to us with more force as the years go past. I believe the truest success will come to those men who are influenced not only by their personal aims and ambitions, but also by those things which are for the good of their country.

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FRICTION IN SMALL AIR PIPES.

PROFESSOR E. G. HARRIS, ALBERT PARK, AND H. K. PETERSON.

The lack of reliable data on friction in small air pipes suggested a suitable field for a graduation thesis. This work was undertaken by Albert Park and H. K. Peterson, students in the class of 1910, of the School of Mines and Metallurgy, University of Missouri. The data and the reductions recorded in Tables 1, 2, 3, and 4 are their work. The apparatus shown in Figs. 1, 2, and 3 was constructed and assembled by them. The remainder of the matter herein was prepared from their data for the purpose of this publication.

The following equipment was used in this work:

One single-stage Rand Imperial type air compressor of 77 cu. ft. per minute free air capacity and pressure up to 100 lbs. per sq. in. gage.

One two-stage Laidlaw-Dunn-Gordon air compressor of 100 cu. ft. free air capacity and 150-lb. gage pressure.

One detached air receiver of 25 cu. ft. capacity.

One drum especially constructed for measuring air by orifice according to the methods* originated by Professor Dudley at McGill University. This drum is supplied with orifices

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*Compressed Air, Vol. II, p. 4181.

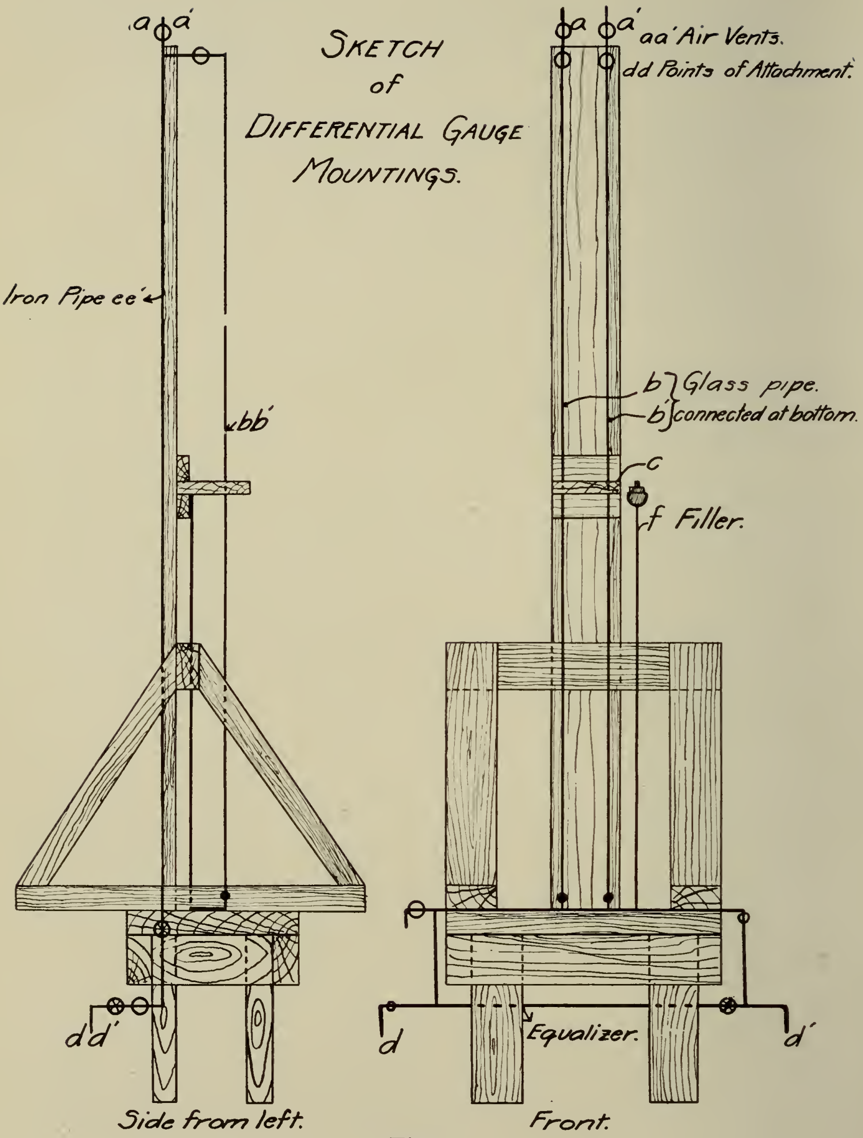
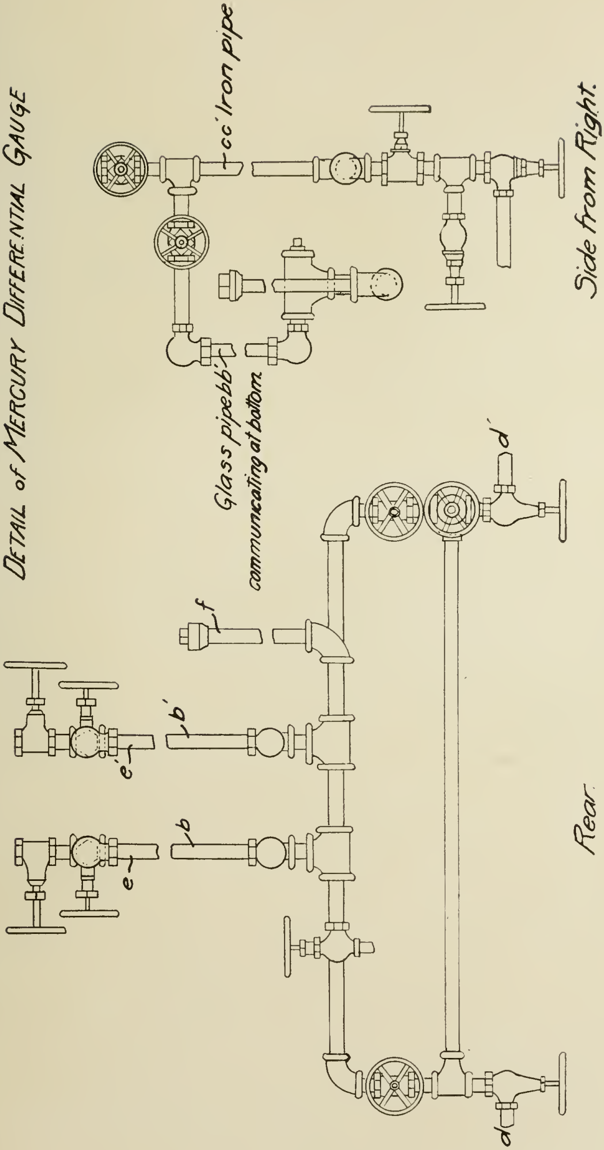

SKETCH
of
DIFFERENTIAL GAUGE
MOUNTINGS.
a a'
Iron Pipe ee'
bb'
d d'
Side from left.
a a' aa' Air Vents.
dd Points of Attachment.
b } Glass pipe.
b' } connected at bottom.
c
f Filler.
Equalizer.
d
d'
Front.

Fig. 1.



DETAIL of MERCURY DIFFERENTIAL GAUGE

Fig. 2.

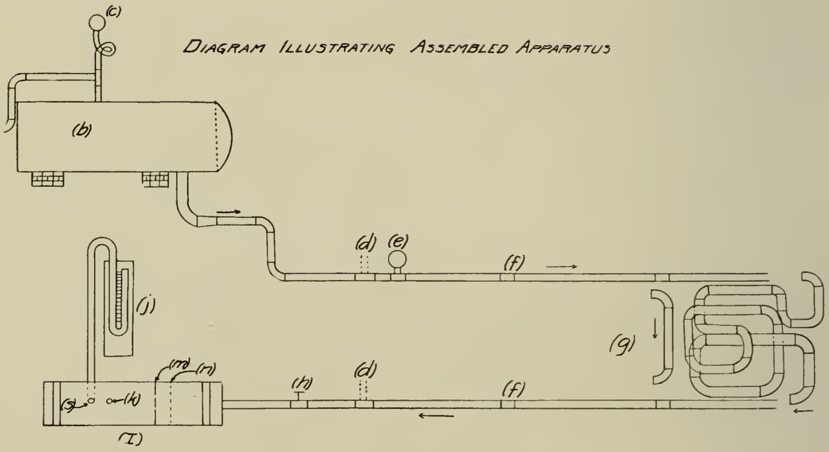


DIAGRAM ILLUSTRATING ASSEMBLED APPARATUS
(c)
(b)
(d)
(e)
(f)
(j)
(g)
(m)
(n)
(h)
(d)
(f)
(s)
(k)
(I)

Fig. 3.

cut in No. 14 copper plate and ranging from one-half inch to three and one-half inches in diameter.

The necessary pressure gages were standard Crosby gages and were tested and the necessary corrections determined by a standard gage tester.

A special differential gage was constructed for this work, and, as the lost pressure ran as high as thirty pounds, the glass tubing was made six feet long. Mercury was used for the indicating fluid in cases of greatest difference of pressure, and water where the difference was small. This gage was constructed by the students. Details are shown in Fig. 1 and Fig. 2. The assembled apparatus is illustrated in Fig. 3.

METHOD OF PROCEDURE IN TAKING DATA.

The free air volume (symbol V_a) was controlled by the speed of the compressors, the pipe connections being so made that the discharges could be united, but the pressure when both compressors were in operation was limited to that of the single-stage machine. The compressor being in steady operation, the pressure was controlled by the throttle valve (h).

The size of the orifice set in the drum was changed as required, to keep the height of water (symbol i) in the U gage within the range covered by Dudley in the experiments before noted.

In each run there were recorded:

1. Reading on differential gage.
2. Reading on U gage.
3. Initial pressure in air pipe.
4. Temperature in air drum.
5. Diameter and length of pipe and number of elbows.
6. Diameter of orifice in air drum.

With each size of pipe two sets of runs were made,—one with two elbows and one with sixteen or eighteen elbows, as shown in the tabulated data. In each set the range of pressure was from zero to about ten atmospheres.

In the runs on two-inch and on one-inch pipes, half of the pipe used was black pipe and half new galvanized pipe—the three-quarter and the half-inch pipe was all new galvanized.

FORMULAS USED IN COMPUTATIONS.

The formulas (20) and (18) following are taken from Compressed Air Computations by Harris and the object of these experiments was to find the value of c in the formula.

$$f = c \frac{l}{d^5} \frac{V_a^2}{r} \tag{20}$$

f = loss of pressure in pounds per square inch.
l = length of pipe in feet.
V_a = volume of free air passing,—cu. ft. per sec.
d = diameter of pipe in inches.
r = ratio of compression,—atmospheres.
c = experimental coefficient.

The free air volume was determined by orifice measurement, using the apparatus heretofore described and applying Dudley's coefficients.

The formula for weight of air passing is

$$Q = K \times 0.1632\, d^2 \sqrt{\frac{i}{t} p_a} \tag{18}$$

which is a modification of that given by Dudley.

The free air volume is

$$V_a = \frac{Q}{W_a}$$

V_a = free air volume in cu. ft. per second.
W_a = weight of one cubic foot of free air.
= .073 pounds, approximately, at Rolla.
Q = weight of air passing the orifice in pounds per second.
d = diameter of orifice in inches.
i = difference in level of water in U tube in inches.
t = absolute temperature of air in drum (F).
p_a = absolute pressure of atmosphere in pounds per sq. in.
= 14.2, approximately, at Rolla.
K = experimental coefficient determined by Dudley.

The f in the friction formula was computed from the differential gage readings, thus:

$$f = \frac{62.5 \times 13.6}{1728} D'' \quad \text{or} \quad f = \frac{62.5 \times 13.6}{1728 \times 2.54} D'$$

where D″ equals difference in height of mercury column in inches and D′ equals difference in centimeters.

The r used in the friction formula (20) was the average in the pipe and was obtained thus:

$$r = \frac{P - \frac{1}{2}f + p_a}{p_a}$$

where P is the gage pressure at entrance.

If the lengths of straight pipe had been the same in the experiments with the greater and with the less number of elbows, the loss due to the extra elbows could have been found directly; but since the lengths were unequal the loss was calculated as follows:

Let f_2 and f_n represent the friction loss in the pipe with two elbows and in the pipe with the greater number, respectively.

Let l_2 and l_n represent the lengths in the two cases.

Let e represent the loss of pressure due to one elbow.

Let $a = \frac{l_2}{d^5}$ and $b = \frac{l_n}{d^5}$,

$$\text{then } f_2 = c\,\frac{l_2}{d^5}\,\frac{V_a^2}{r} + 2e = ca\,\frac{V_a^2}{r} + 2e \qquad \text{(A)}$$

$$\text{and } f_n = c\,\frac{l_n}{d^5}\,\frac{V_a^2}{r} + ne = cb\,\frac{V_a^2}{r} + ne \qquad \text{(B)}$$

multiply (A) by $\frac{n}{2}$, —subtract one from the other,—solve for c and get

$$c = \frac{\frac{n}{2}\,f_2 - f_n}{\left(a\frac{n}{2} - b\right)\frac{V_a^2}{r}} \qquad \text{(C)}$$

In this equation it is assumed that the $\frac{V_a^2}{r}$ is the same for the values of f_2 and f_n but the experiments could not be controlled to this extent. To overcome this difficulty, the values of f_2 and f_n were platted as vertical ordinates over $\frac{V_a^2}{r}$ as horizontal ordinates and smooth curves drawn through the points with the intention of taking therefrom values of f_2 and f_n corresponding to any desired values of $\frac{V_a^2}{r}$ and with these to compute the c.

These points when platted seem to indicate that values of f_2 and f_n can be taken as varying as the ordinate to a straight line over values $\frac{V_a^2}{r}$ except in the case of the two-inch pipe; and in that case the curve is so flat that for practical purposes a straight line can be drawn up to where the velocity of air in the pipe exceeds fifty feet per second.

The curves for the two-inch pipe are shown in Plate 5 and the modification giving the straight lines is on Plate 4.

Assuming, then, that f_2 and f_n vary directly with $\frac{V_a^2}{r}$ in cases with and without elbows, the solution of equation (C) is much simplified, for it can now be written

$$c = \frac{\frac{n}{2}g - h}{\frac{n}{2}a - b}$$

where $f_2 = g\frac{V_a^2}{r}$ and $f_n = h\frac{V_a^2}{r}$ the $\frac{V_a^2}{r}$ canceling.

On each plat the values of n, a, b, g, h, and c are recorded.

RESISTANCE IN ELBOWS.

Write equations (A) and (B) thus:

$$f_2 = g\frac{V_a^2}{r} = ca\frac{V_a^2}{r} + 2e$$

$$f_n = h\frac{V_a^2}{r} = cb\frac{V_a^2}{r} + ne$$

Solve for e and get

$$e = \left[\frac{g + h - c\,(a + b)}{n + 2}\right]\frac{V_a^2}{r}$$

From this the value of e for any value of $\frac{V_a^2}{r}$ can be computed, but it is much more convenient to find the length of straight pipe that will for all values of $\frac{V_a^2}{r}$ give the same loss as one elbow. This can be done as follows:

If, in the formula for loss in a straight pipe, viz.:

$$f = c\,\frac{l}{d^5}\;\frac{V_a^2}{r}$$

we make $f = e$ and compute l, the length so computed will be the equivalent length sought. Thus:

$$e = \left[\frac{g + h - c\,(a + b)}{n + 2}\right]\frac{V_a^2}{r} = c\,\frac{l_e}{d^5}\,\frac{V_a^2}{r}$$

Whence $$l_e = d^5\left[\frac{\frac{g + h}{c} - (a + b)}{n + 2}\right]$$

Using the values already determined and recorded on Plates 1 to 5, the values of l_e are as follows:

Diameter of pipe in inches..........	2	1	¾	½
Length of pipe in feet causing a loss equivalent to one elbow...........	6.5	5.9	8.2	12.3

These results are for standard short-turn elbows.

It is noteworthy that these results differ radically from the equivalents given in other publications.

The observations on elbow resistance do not cover a sufficient number of diameters to warrant any general conclusions or any effort to determine the law of variation. More such experiments over a wider field are needed.

AVERAGE VALUES OF COEFFICIENT OF FRICTION.

In addition to the values of the friction coefficient c as herein determined for pipes up to two inches, we have presumably reliable data on larger pipes from which the coefficient has been determined as follows:

Experiments by Guttermuth and Reidler on Paris mains in 1890—diameter 12″, neglecting the evidently abnormal cases, $c = .050$.

Experiments by Stockhalper at St. Gothard tunnel; $d = 8''$; $c = .062$.

Experiments by Devillez at Levant Du Flenn, 1879; $d = 5''$; $c = .057$.

Experiments by Lorens at Offenbach, 1892; $d = 4''$; $c = .066$.

Experiments by Devillez at Levant Du Flenn, 1879; $d = 3''$; $c = .072$.

These computed values of c are here tabulated:

Diameter (inches)..	½	¾	1	2	3	4	5	6	8	12
Friction Coefficient	.075	.061	.071	.073	.072	.066	.057	.056	.062	.050

These results are shown platted on Plate 6. The coefficients for three-quarter and for five-inch pipes seem abnormal and were neglected in locating the straight line average.

The straight line shown on Plate 6 gives the equation $c = .076 - .00188d$, and from this the following coefficients were obtained and are recommended for practice until more extended data is obtained:

d	½	1	1½	2	2½	3	3½	4	4½	5	6	7	8	10	12
c	.075	.074	.073	.072	.071	.070	.070	.069	.068	.067	.065	.063	.061	.059	.054

TABLES

The significance of the symbols in the following tables is as follows:

D' = differential gage reading in centimeters of mercury.
D'' = differential gage reading in inches of mercury.
i = U gage reading in inches of water.
r = ratio of compression in atmospheres.
t = temperature (centigrade) in air drum.
V_a = volume of free air passing in cu. ft. per second.
S = velocity of air in pipe, — ft. per second.
f = loss of pressure in pounds per square inch.

TABLE NUMBER ONE.

Part One.

Data on two-inch pipe. Two elbows.

Length of pipe 205.9′. Diameter of orifice 2.5″.

No.	D''	i	r	t_c	V_a	S	f	$\frac{V_a^2}{r}$
1	1.3	2.7	3.6	19.	2.27	28.9	0.63	1.43
2	2.1	3.15	2.9	20.	2.45	38.7	1.03	2.06
3	2.8	3.9	2.4	20.5	2.72	51.96	1.37	3.08+
4	4.8	4.0	1.6	20.5	2.76	78.93	2.36	4.74+
5	5.7	3.95	1.2	21.0	2.74	104.6	2.80	6.24+
6	0.5	1.45	6.2	20.0	1.66	12.27	0.24	0.44
7	0.8	2.6	7.3	20.5	2.22	13.95	0.39	0.67
8	0.8	3.15	8.0	21.0	2.44	14.00	0.39	0.74

Part Two.

Data on two-inch pipe. Sixteen elbows.

Length of pipe 208.1′. Diameter of orifice 2.5″.

No.	D''	i	r	t_c	V_a	S	f	$\frac{V_a^2}{r}$
1	0.3	1.0	9.60	24.0	1.37	6.54	.1476	.1954
2	0.4	1.1	8.96	24.5	1.44	7.35	.1968	.2299
3	0.5	1.7	8.19	25.0	1.78	9.98	.2460	.3881
4	1.1	2.8	7.13	22.0	2.30	14.80	.5410	.7416
5	1.6	3.6	6.21	21.0	2.61	19.30	.7871	1.0990
6	2.3	4.2	4.80	20.5	2 83	26.90	1.1320	1.6610
7	2.8	4.2	3.75	20.5	2.83	34.50	1.3780	2.1260
8	3.6	4.2	2.68	20.5	2.83	48.30	1.7710	2.9750+
9	5.5	4.5	1.97	21.0	2.92	67.40	2.0760	4.3280+
10	8.6	5.5	1.41	22.0	3.22	104.8	4.2310	7.366 +

TABLE NUMBER TWO.

PART ONE.

Data on one-inch pipe. Two elbows.

Length of pipe 208.1′. Diameter of orifice 1.75″.

No.	D''	i	r	t_c	V_a	S	f	$\frac{V_a^2}{r}$
1	1.7	1.3	10.7	30	.76	13	.84	.054
2	0.8	0.6	10.6	30	.52	8.9	.39	.025
3	2.5	1.7	9.7	30	.87	16.4	1.23	.077
4	6.0	3.7	8.6	30	1.24	26.5	2.95	.179
5	10.8	5.6	7.7	29	1.58	37.5	5.31	.322+
6	8.2	4.9	7.3	29	1.47	37.0	4.03	.297+
7	6.6	2.4	5.9	28.5	1.03	32.1	3.25	.180
8	7.0	2.1	4.9	28	.966	36.15	3.44	.190
9	10.0	2.1	3.6	28	.966	49.2	4.92	.259+
10	5.1	0.9	2.7	28	.632	42.9	2.50	.148
11	8.2	1.0	1.9	28	.666	42.9	4.03	.233
12	2.9	0.3	1.3	27	.366	19.5	1.43	.103

PART TWO.

Data on one-inch pipe. Eighteen elbows.

Length of pipe 210.65′. Diameter of orifice 1.75″.

No.	D''	i	r	t_c	V_a	S	f	$\frac{V_a^2}{r}$
1	7.4	1.1	2.62	35	.69	48.4	3.6	.1824
2	9.9	1.0	1.87	35	.659	64.7	4.9	.2323+
3	8.1	.8	1.21	35	.589	89.4	4.0	.2872
4	8.7	2.1	4.9	34	.956	35.8	4.3	.1868
5	11.1	2.3	4.0	34	1.000	46.5	5.5	2536+
6	4.0	1.0	3.03	34	.66	40.0	1.97	.1438
7	9.8	3.0	5.5	34	1.143	38.5	4.8	.2403+
8	10.8	3.3	6.13	33.5	1.20	36.0	5.3	.2350+
9	7.0	2.5	7.0	33.5	1.05	27.5	3.5	.1566
10	5.2	2.2	7.75	33	.981	23.2	2.6	.1241
11	5.7	2.4	8.38	33	1.03	22.4	2.8	.1252
12	4.1	2.0	10.7	32.5	.94	16.0	2.1	.0817
13	8.4	4.3	9.94	32.5	1.37	25.0	4.1	.1894
14	11.4	5.0	8.84	32.5	1.48	30.7	5.6	.2477

TABLE NUMBER THREE.

PART ONE.

Data on three-fourth inch pipe. Two elbows.

Length of pipe 201.8′. Diameter of orifice 1.75″.

No.	D'	i	r	t_c	V_a	S	f	$\frac{V_a^2}{r}$
1	37.3	.5	1.3	39.5	.426	116.0	7.21	.1647
2	63.8	.9	1.62	40.0	.620	124.8	12.3	.2374
3	116.3	2.4	2.5	40.0	1.013	135.3	22.5	.4204
4	117.0	3.2	3.4	39.0	1.171	114.	22.6	.4096
5	158.9	5.6	4.1	38.5	1.551	124.	30.7	.5866
6	73.5	3.4	5.7	39.0	1.207	69.	14.21	.2558
7	96.8	4.9	6.6	40.0	1.447	71.	18.7	.3159
8	78.8	4.5	7.5	40.0	1.387	61.	15.3	.2520
9	48.2	2.8	8.7	40.0	1.094	41.	8.54	.1088
10	39.6	2.9	9.96	48.5	1.110	36.	7.64	.1239

PART TWO.

Data on three-fourth inch pipe. Sixteen elbows.

Length of pipe 208.2′. Diameter of orifice 1.75″.

No.	D'	i	r	t_c	V_a	S	f	$\frac{V_a^2}{r}$
1	74.0	.9	1.55	24.5	.6361	133.8	14.3	.2651
2	41.5	.5	1.34	26.5	.4726	115.0	8.1	.1667
3	81.4	1.1	2.2	28.0	.6992	103.6	15.74	.2220
4	107.4	2.1	3.1	29.5	.9637	102.7	20.8	.3035
5	141.4	2.9	3.96	30.5	1.131	93.1	27.4	.3228
6	165.8	4.4	4.84	33.	1.387	93.4	32.1	.3974
7	164.5	5.2	6.04	34.	1.506	81.3	31.8	.3751
8	111.0	4.4	7.24	35.5	1.382	62.2	21.5	.2635
9	117.2	5.1	8.24	38.	1.481	58.6	22.7	.2662
10	96.8	4.7	9.36	38.	1.422	49.5	18.7	.2160
11	47.9	2.8	10.5	37.5	1.099	38.2	9.19	.1153

TABLE NUMBER FOUR.

PART ONE.

Data on one-half inch pipe. Two elbows.

Length of pipe 161.1′. Diameter of orifice 0.75″.

No.	D'	i	r	t_c	V_a	S	f	$\frac{V_a^2}{r}$
1	50.5	3.3	2.05	16	.2270	81.3	9.77	.0251
2	41.5	4.3	3.76	15	.2596	50.6	8.03	.0178
3	26.0	3.1	4.95	15	.2204	32.6	3.03	.0098
4	7.2	1.3	5.63	14	.2430	18.6	1.39	.0036
5	35.5	5.7	6.14	14	.2994	35.8	6.87	.0746+
6	42.0	7.0	6.31	14	.3318	38.6	8.12	.0174
7	50.0	8.7	5.97	14	.3699	45.5	9.84	.0229
8	27.2	4.6	6.83	22	.2653	28.5	5.26	.0103
9	33.6	5.0	9.86	23	.2761	20.6	6.50	.0077+

PART TWO.

Data on one-half inch pipe. Eighteen elbows.

Length of pipe 168.5′. Diameter of orifice 0.75″.

No.	D'	i	r	t_c	V_a	S	f	$\frac{V_a^2}{r}$
1	50.7	5.2	8.2	19.5	.283	25.4	9.81	.0097
2	44.6	5.0	8.74	19.5	.278	23.3	8.63	.0088
3	36.1	4.5	9.56	20.0	.263	20.2	6.98	.0072
4	134.3	4.9	2.54	27.5	.273	78.8	25.9	.0293
5	117.1	5.3	3.35	25.5	.283	62.0	22.7	.0239
6	85.4	5.3	4.62	25.5	.283	45.0	16.5	.0173
7	41.2	3.6	6.03	25.5	.233	28.4	7.97	.0090
8	40.8	4.0	7.01	25.5	.246	25.7	7.91	.0086
9	6.0	1.3	7.95	25.5	.140	12.9	1.16	.0025

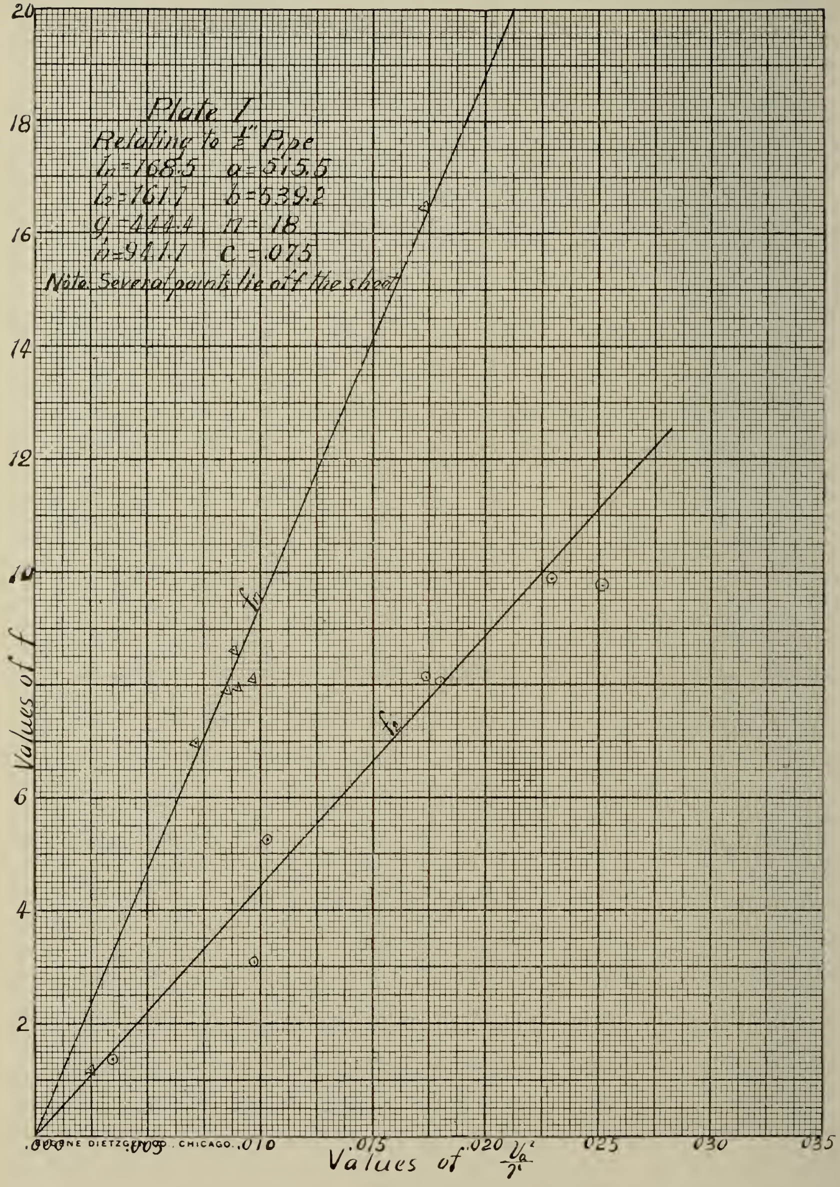
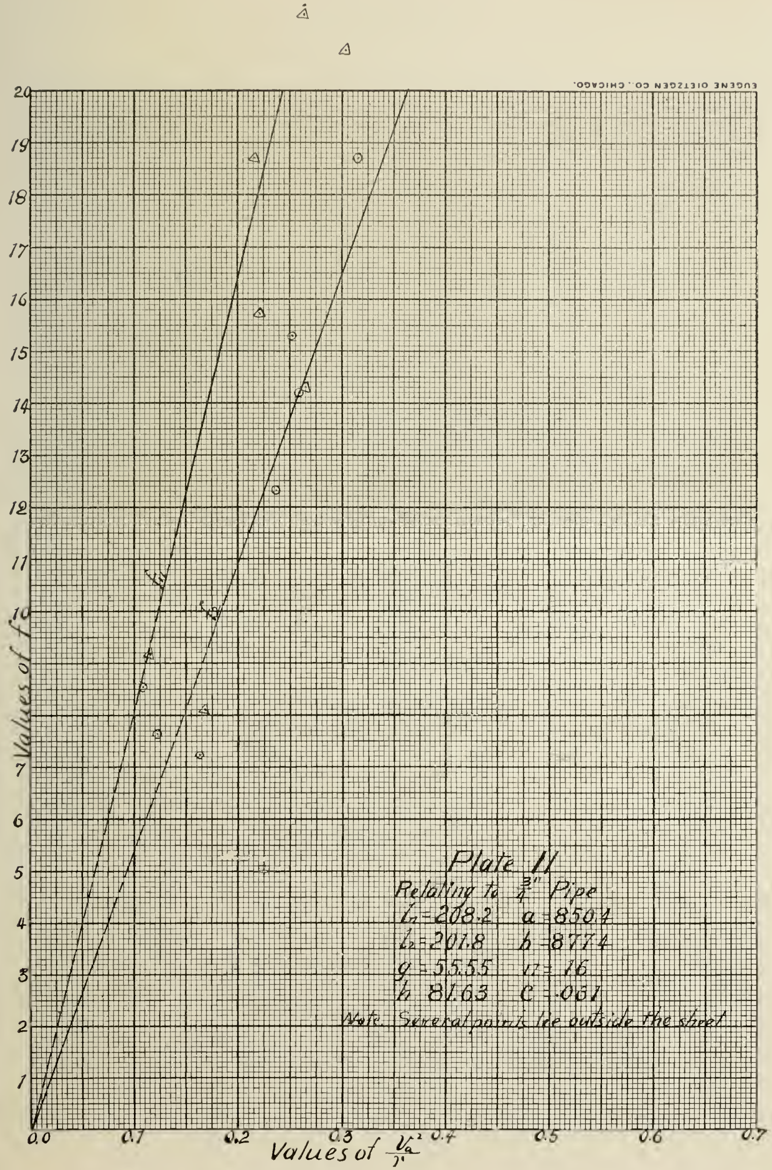


Plate I
Relating to ½" Pipe
l_1=168.5
a=515.5
l_2=161.7
b=539.2
g=444.4
m=18
h=94.1.7
C=.075
Note. Several points lie off the sheet
f_1
f_2
20
18
16
14
12
10
6
4
2
Values of f
.000
.005
.010
.015
.020
.025
.030
.035
EUGENE DIETZGEN CO. CHICAGO.
Values of $\frac{V_a^2}{r^2}$


EUGENE DIETZGEN CO., CHICAGO.
Values of f
Values of $\frac{V_a^2}{r}$
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1
2
3
4
5
6
7
10
11
12
13
14
15
16
17
18
19
20
Plate II
Relating to $\frac{3}{4}''$ Pipe
l_1 = 208.2
l_2 = 201.8
g = 55.55
h 81.63
a = 8504
b = 8774
v = 16
C = ·061
Note. Several points lie outside the sheet

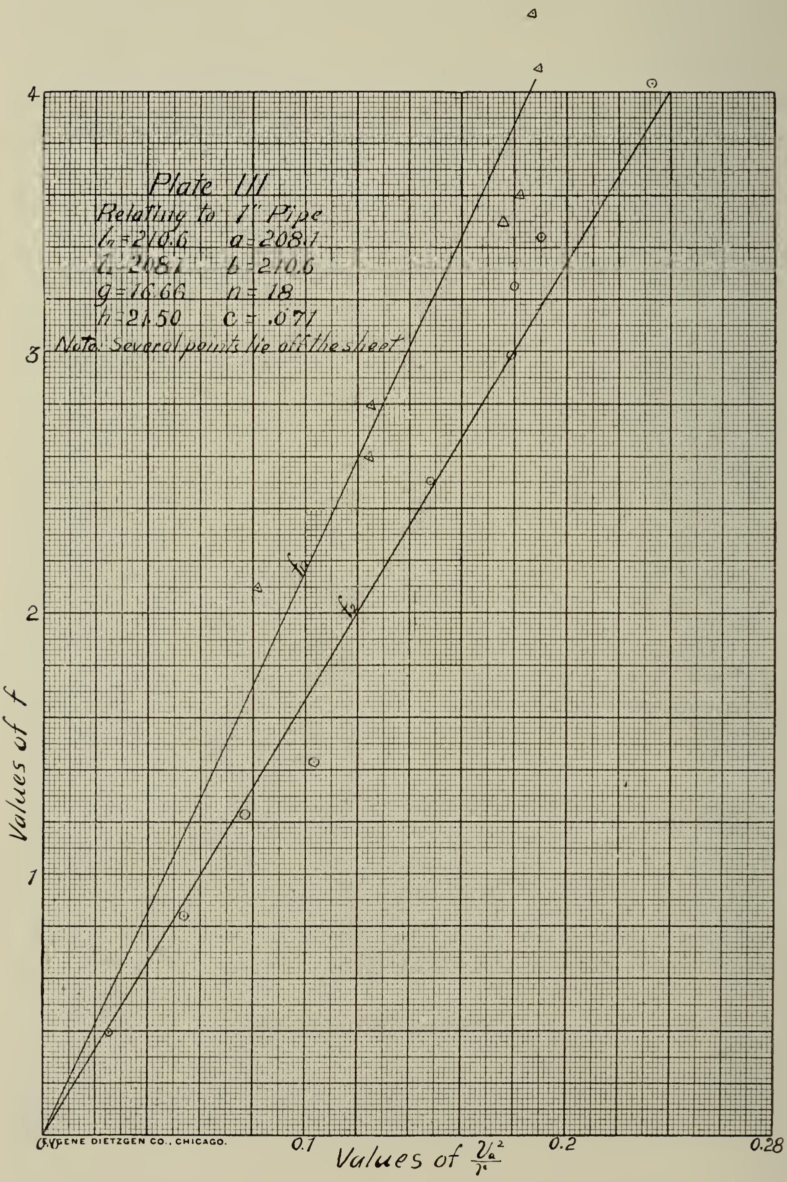


Plate III
Relating to 1" Pipe
l_1=210.6
l=208.1
g=16.66
h=21.50
a=208.1
b=210.6
n=18
c=.071
Note: Several points lie off the sheet
f_1
f_2
4
3
2
1
Values of f
0.0
0.1
0.2
0.28
Values of $\frac{V_a^2}{r}$
EUGENE DIETZGEN CO., CHICAGO.

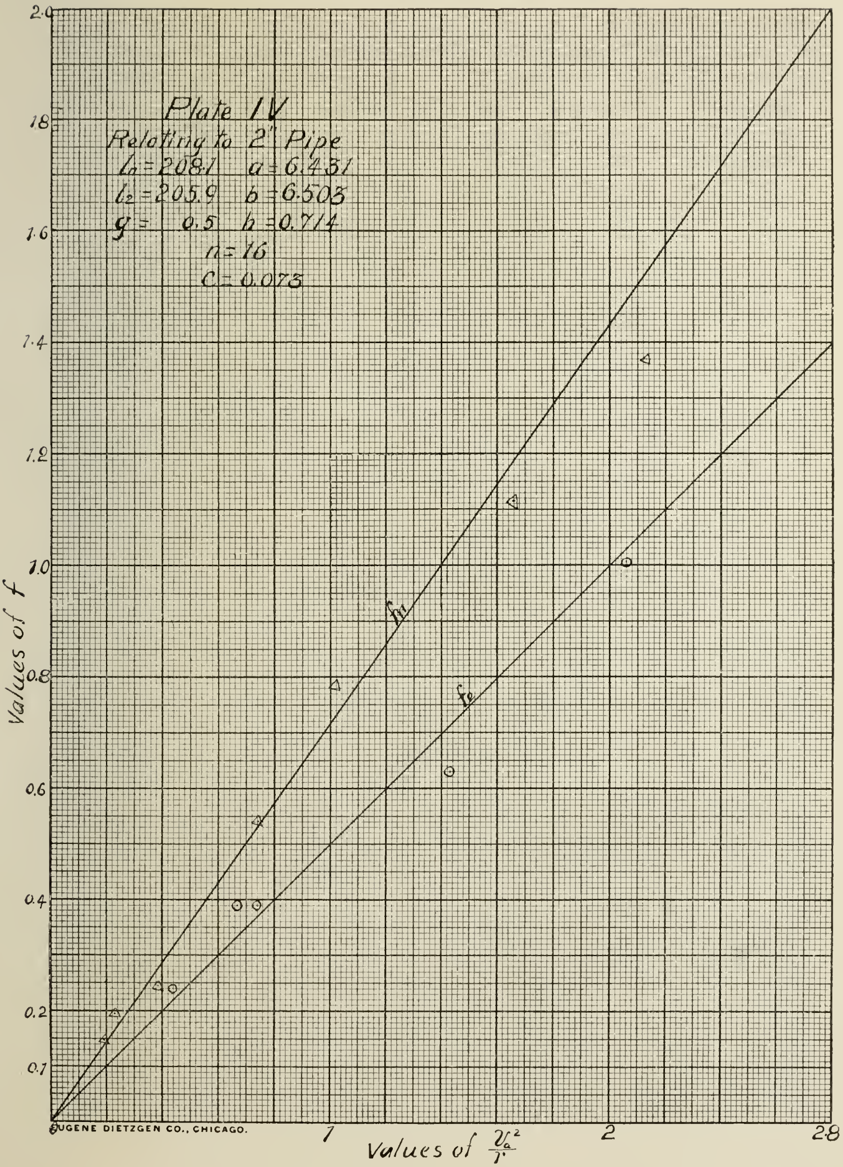


Plate IV
Relating to 2" Pipe
l_1 = 208.1 a = 6.431
l_2 = 205.9 b = 6.503
g = 0.5 h = 0.714
n = 16
C = 0.073
fr
fe
Values of f
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.1
0
1
2
2.8
Values of $\frac{V_a^2}{r}$
EUGENE DIETZGEN CO., CHICAGO.

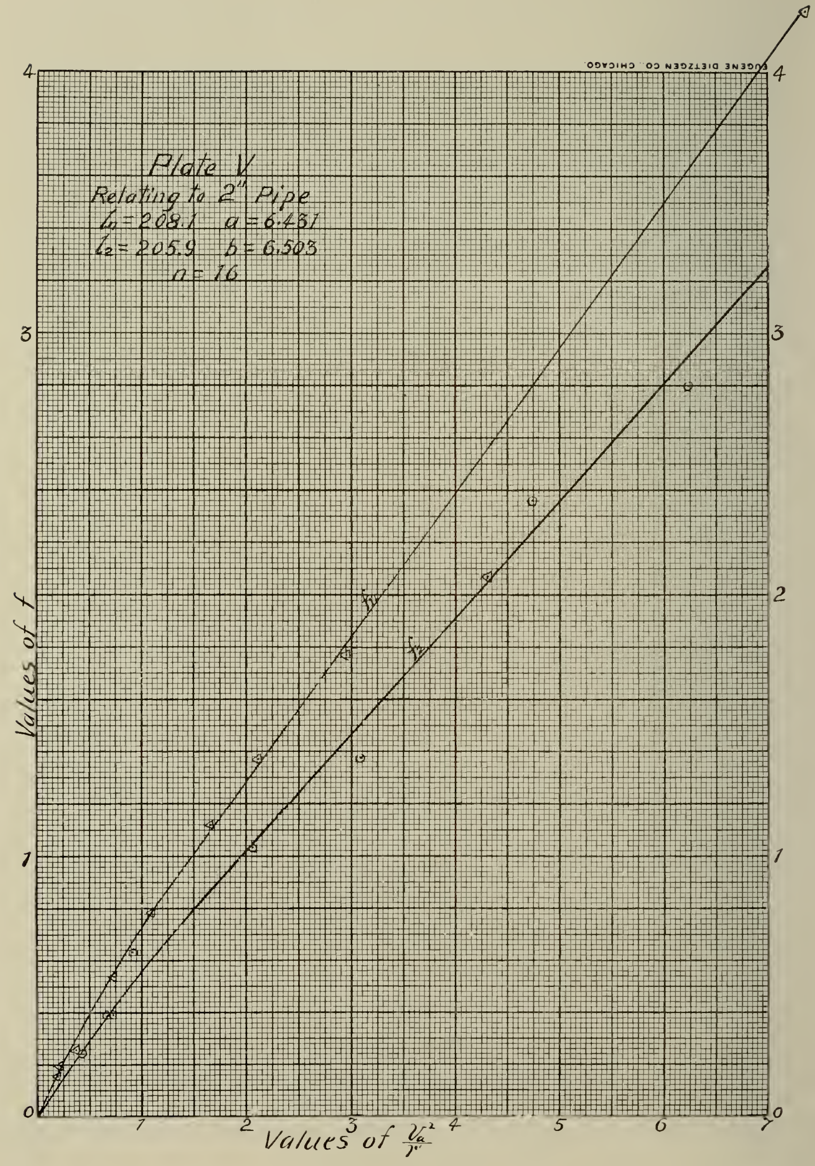


Plate V
Relating to 2" Pipe
l_1 = 208.1 a = 6.431
l_2 = 205.9 b = 6.503
n = 16
f_1
f_2
Values of f
Values of $\frac{V_a^2}{r}$
0
1
2
3
4
5
6
7
EUGENE DIETZGEN CO. CHICAGO.

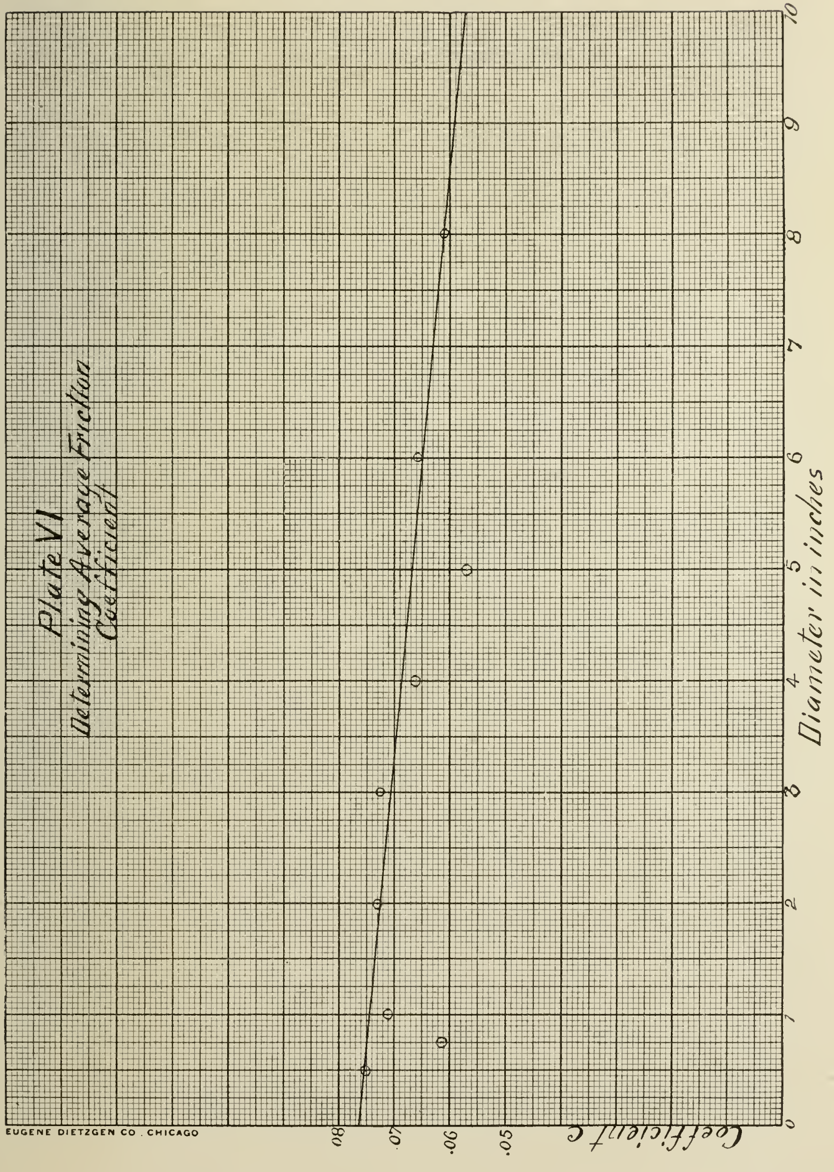


Plate VI
Determining Average Friction Coefficient
Diameter in inches
0
1
2
3
4
5
6
7
8
9
10
Coefficient c
.08
.07
.06
.05
EUGENE DIETZGEN CO. CHICAGO

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